PB90-226077

Direct/Delayed Response Project: Field Operations and Quality Assurance Report for Soil Sampling in the Mid-Appalachian Region of the United States

(U.S.) Corvallis Environmental Research Lab., OR

Jun 90

U.S. Department of Commerce
National Technical Information Service
NTIS

PB90-226077

EPA/600/3-90/045
June 1990

DIRECT/DELAYED RESPONSE PROJECT:
FIELD OPERATIONS AND QUALITY ASSURANCE REPORT FOR SOIL SAMPLING IN THE MID-APPALACHIAN REGION OF THE UNITED STATES

by

Jeffrey S. Kern
NSI Technology Services Corporation
USEPA Environmental Research Laboratory
200 SW 35th Street
Corvallis, Oregon 97333

Jeffrey J. Lee
US Environmental Protection Agency
USEPA Environmental Research Laboratory
200 SW 35th Street
Corvallis, Oregon 97333

US Environmental Protection Agency
USEPA Environmental Research Laboratory
200 SW 35th Street
Corvallis, Oregon 97333

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL
INFORMATION SERVICE
SPRINGFIELD, VA 22161

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA/600/3-90/045

2.

3. RECIPIENT'S ACCESSION NO. PB90 226077/AS

4. TITLE AND SUBTITLE

Direct/Delayed Response Project: Field Operations and Quality Assurance Report for Soil Sampling in the Mid-Appalachian Region of the United States

5. REPORT DATE June 1990

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)

Jeffrey S. Kern[1], and Jeffrey J. Lee[2],

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS

[1]NSI, ERL-CORVALLIS, AND [2]US EPA,
Environmental Research Lab, Corvallis, OR

10. PROGRAM ELEMENT NO.

11. CONTRACT/GRANT NO.

12. SPONSORING AGENCY NAME AND ADDRESS

US Environmental Protection Agency
Environmental Research Laboratory
200 SW 35th Street
Corvallis, OR 97333

13. TYPE OF REPORT AND PERIOD COVERED Published Report

14. SPONSORING AGENCY CODE EPA/600/2

15. SUPPLEMENTARY NOTES

1990. US Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR.

16. ABSTRACT

The Direct/Delayed Response Project (DDRP) has been designed and implemented by the U.S. Environmental Protection Agency to reduce uncertainties in current understanding of the effects of acidic deposition on surface waters chemistry. The response of watersheds to acidic deposition is being assessed for selected study regions using data from DDRP watershed surveys, USEPA surface water surveys, and acidic deposition data. This document describes the planning activities, field activities, and the quality assurance/quality control (QA/QC) operations associated with soil sampling in the Mid-Appalachian Region of the United States. The watersheds mapped were chosen from those studied by the USEPA National Surface Water Survey.

The objective of the soil sampling was to collect samples to characterize the physical and chemical properties of soil from watersheds that were mapped by the DDRP. The activities resulted in 100 percent of the selected pedons being sampled.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT

Release to Public

19. SECURITY CLASS (This Report) Unclassified

20. SECURITY CLASS (This page) Unclassified

21. NO. OF PAGES 211

22. PRICE

EPA Form 2220-1 (9-73)

NOTICE

The research described in this report has been funded wholly by the US Environmental Protection Agency. It has been subjected to the Agency's peer and administrative review, and it has been approved for publication as an USEPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

EXECUTIVE SUMMARY

The Direct/Delayed Response Project (DDRP) of the National Acid Precipitation Assessment Program is a United States Environmental Protection Agency (USEPA) program to reduce the uncertainties in current understanding of the effects of acidic deposition on surface water chemistry. The response of watersheds to acidic deposition is being assessed for selected study regions using data from DDRP watershed surveys, USEPA surface water surveys, and acidic deposition data. This document describes the planning activities, field activities, and the quality assurance/quality control (QA/QC) operations associated with soil sampling in the Mid-Appalachian Region of the United States. The watersheds mapped were chosen from those studied by the USEPA National Surface Water Survey.

The objective of the soil sampling was to collect samples to characterize the physical and chemical properties of soil from watersheds that were mapped by the DDRP. Routine bulk samples, duplicate samples, and bulk density samples were collected from pedons according to protocols that are included as Appendix A. A pedon is an area of soil that is large enough to represent the nature and variability of soil horizons and features present. The soil scientists handled several types of samples every third pedon that were designed to assess sample precision, potential contamination, and sampling bias. Samples were kept cool and were then shipped by overnight carrier to a preparation laboratory. The QA design and QC activities for the sampling is presented in the QA plan that is included as Appendix B.

The sampling protocols were revised from previous DDRP surveys prior to beginning the fieldwork. Comparability between DDRP surveys was promoted by using basically the same protocols throughout the project. Revisions of the protocols include the addition of new bulk density methods to ensure greater completeness, new types of quality assessment samples, a structured logbook, and revised sample shipment procedures. The principal soil scientists involved in the sampling attended a sampling training workshop before the sampling began. The workshop presented an overview of the sampling protocols and demonstrated the new bulk density methods.

Field visits were conducted by US Department of Agriculture - Soil Conservation Service (SCS) State Soils Staffs, the DDRP Regional Coordinator/Correlator (RCC), and representatives of the USEPA. The objectives of the field visits were to observe whether or not crews were following the protocols, to answer questions about the protocols, and to verify that soil samples collected were representative of the selected pedons. The State Soils Staffs and the RCC prepared an independent site and soil profile description for each field visit to assess the correctness of the routine description. The independent describers discussed differences in the descriptions before sampling if there was any difference that would affect sample quality.

The State Soils Staffs conducted at least one field visit for each crew from their state. Some of the reviews were held in conjunction with the RCC's review. No major problems were identified during these visits. Issues discussed included suitable vegetation for site selection, the identification of argillic horizons, and the collection of field duplicate samples. The independent descriptions did not indicate any problem with site and soil profile descriptions.

The RCC visited each of the original four sampling crews once. The RCC did not visit the crew that was later added because the personnel had been evaluated earlier by the RCC while they were members of the other crews. The RCC concluded that the crews were following protocols. Issues discussed were the size of clod bulk density samples, the collection of field duplicate samples, and the need for more frequent sample shipments. The independent descriptions by the RCC did not indicate any problem with site and soil profile descriptions.

The DDRP Soils QA Coordinator from the USEPA Environmental Research Laboratory, Corvallis conducted 1 field visit for each crew and a second visit for 3 of the original 4 crews. The first visits were early in the sampling project to clarify any questions or problems with the protocols. The second visits were made during the middle of the sampling project. One WV crew finished sampling before a second visit was possible. No major problems were identified during these visits. Issues that did arise were acceptable vegetation for site selection, the method for sampling duplicates, the appropriate labeling of zero depth for the descriptions, the size of clod bulk density samples, exact site locations, and sample storage.

The activities resulted in 100 percent of the selected pedons being sampled. Two field duplicates were incorrectly sampled, but all subsequent field duplicates were correctly sampled. The completeness for bulk density samples was 98 percent compared to 48 percent and 61 percent achieved in previous DDRP sampling efforts. The analysis of quality control samples at the preparation laboratory indicated that there was no detectable contamination or sampling bias. Evaluation of information from analytical laboratories suggested that one pedon was sampled from a site that had been contaminated by agricultural wastes and one pedon had some contamination to the surface horizon because of agricultural liming.

TABLE OF CONTENTS

NOTICE ii

EXECUTIVE SUMMARY iii

FIGURES vii

TABLES viii

ACKNOWLEDGEMENTS ix

1 INTRODUCTION 1
    PROJECT DESCRIPTION 1
    WATERSHED SELECTION 4
    SOIL SURVEY DESIGN 4
        Project Organization and Personnel 7
        Sampling Classes 7
        Selection of Potential Sampling Sites 8
    FIELD PROCEDURES 11
        Selection of Actual Pedon Sampling Sites 11
        Pit Excavation 12
        Site and Soil Profile Description 12
        Photographic Documentation 13
        Sampling 13
            Bulk Soil Sampling-- 13
            Quality Control Samples-- 14
            Bulk Density Samples-- 15
        Sample Transportation, Storage, and Shipment 16

2 FIELD OPERATIONS 18
    PREPARATION FOR FIELD OPERATIONS 18
        Development of Protocols 18
        Preparation Laboratory 18
        Contracting Sampling Personnel 19
        Pilot Soil Sampling 19
        Sampling Crew Training 20
    SOIL SAMPLING 20
        Sampling Equipment 20
        Site Selection 21
            Site Restrictions-- 21
            Sampling Classes-- 21
            Vegetation Class Considerations-- 25
        Pedon Excavation 26
        Site and Soil Profile Description 26
        Photographic Documentation 27
        Bulk Sampling 27
            Possible Sample Contamination-- 28
        Field Duplicate Sampling and Quality Control Samples 28
        Bulk Density Sampling 29
            Clod Sampling-- 30
        Alternative Bulk density Methods 30
            Volume-Replacement Sampling-- 30
            Volume-Fill Sampling-- 30

Sample Labeling 31
Crew Logbooks 31
Sample Transport and Storage 31
Exit Meeting 32
Conclusions About Soil Sampling 33

3 QUALITY ASSURANCE (QA) PROGRAM 35
QA PROGRAM DESIGN 35
MEASUREMENT QUALITY OBJECTIVES 35
LABORATORY ANALYSES 36
Preparation Laboratory 36
Analytical Laboratories 36
AUDITS 36
RCC Field Visits 38
State Soils Staffs Field Visits 39
US Environmental Protection Agency Quality Assurance Audits 40
INDEPENDENT SOIL PROFILE DESCRIPTIONS 43
PA105001 44
PA099003 45
PA055001 46
PA027003 47
WV093006 47
WV075006 48
WV093002 49
Independent Description Conclusions 49

4 CONCLUSIONS AND RECOMMENDATIONS 50
TRAINING 50
SITE SELECTION 50
SITE AND SOIL PROFILE DESCRIPTIONS 50
PHOTOGRAPHIC DOCUMENTATION 51
BULK SAMPLING 51
Bulk Density 51
CREW LOGBOOKS 51
AUDITS 52
INDEPENDENT SITE AND SOIL PROFILE DESCRIPTIONS 52
STORAGE AND TRANSPORTATION 52
OVERALL CONCLUSIONS 52

5 REFERENCES 54

APPENDIX A SOIL SAMPLING MANUAL 57

APPENDIX B QUALITY ASSURANCE PLAN 127

APPENDIX C RCC QA/QC REPORT OF SOIL SAMPLING 189

FIGURES

Figure 1-1 Study Regions for the DDRP 2
Figure 1-2 Subregions of the National Stream Survey 6
Figure 1-3 Sampling Class Flowchart for the DDRP Mid-Appalachian Survey 9

TABLES

Table 1-1 Locations of the DDRP Mid-Appalachian Watersheds 5
Table 1-2 Sampling Classes for Two Non-Sedimentary Bedrock Watersheds 10
Table 2-1 Summary of Soil Sampling Activities 21
Table 2-2 Pedons Reported to Have Borderline Argillic Development 23
Table 2-3 Pedon Reported to Have Borderline Fragipan Development 24
Table 2-4 Pedons Reported to Have Borderline Drainage Classes 24
Table 2-5 Pedons Without Photographic Documentation 27
Table 2-6 Samples with Possible Contamination 29
Table 3-1 Flagged Samples From Preparation Laboratory Analyses 37
Table 3-2 Audits of Field Crew 38
Table 3-3 Identification Numbers and Authors of the Independent Descriptions 44

ACKNOWLEDGEMENTS

The field work for the sampling activities was carried out by soil scientists from the US Department of Agriculture - Soil Conservation Service (SCS) from Pennsylvania and West Virginia. The Regional Coordinator/Correlator was John Warner Jr, soil scientist consultant, Marco, Florida.

The SCS soil scientists who participated in the Mid-Appalachian soil sampling were:

Pennsylvania

Scott Anderson
John Chibirka
Norman Churchill
Timothy Craul
Boyd Custer
Joseph Eckenrode
Ned Ellenberger
Joseph Hallowich
John Hudak
Robert Knight
Garland Lipscomb
George Martin
Regina Schweinsberg
Daniel Seibert
Edgar White
J. Ann Wilkins

West Virginia

Doug Adamo
Paul Amick
James Bell
Charles Delp
Ron Estepp
Ross Fugill
Tony Jenkins
Cheryl Lobb
Cameron Loerch
Mary Ellen McFadden
Robert Pate
Barrie Wolf

The technical monitors for the soil preparation laboratory for this project were Louis Blume and Daniel Heggam, US Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Las Vegas, Nevada. The laboratory manager was Rick Van Remortel of Lockheed Engineering and Sciences Company, Las Vegas, Nevada. Henry Mount of the SCS Quality Assurance Staff, Lincoln, Nebraska, provided valuable assistance.

Suzanne Pierson of NSI-Technology Services Corporation, Corvallis, Oregon, prepared the maps in this report. Carol Roberts of NSI-Technology Services Corporation, Corvallis, Oregon, assisted in wordprocessing this report. The external reviewers for this report were Richard Rust, University of Minnesota, St Paul, Minnesota, Keith Wheeler, Adirondack Park Agency, Paul-Smiths, New York, and Gerald McCormick, SCS, Virginia, Minnesota.

1 INTRODUCTION

This report documents the soil sampling activities of the Direct/Delayed Response Project (DDRP) in the Mid-Appalachian Region of the United States. The objectives of this report are to document the methods, field operations, and quality assurance (QA) activities conducted during the sampling. The protocols, QA plan, and an independent QA report are presented as appendices.

PROJECT DESCRIPTION

The DDRP is an integral component of the acidic deposition research program of the US Environmental Protection Agency (USEPA). It is conducted under the federally mandated National Acid Precipitation Assessment Program (NAPAP). The DDRP is managed by the USEPA Environmental Research Laboratory - Corvallis (ERL-C). Previous DDRP soil sampling activities in the Northeast Region (NE) and Southern Blue Ridge Province (SBRP) of the US are documented by Coffey et al. (1987a; 1987b).

The general goal of the DDRP is to reduce the uncertainties in current understanding of the effects of acidic deposition on surface water chemistry. The response of watersheds to acidic deposition is being assessed for the study regions using data from DDRP watershed surveys in the NE, the SBRP, and the Mid-Appalachian Region (Figure 1-1), results from the National Surface Water Survey (NSWS), and deposition data.

The four technical objectives of the DDRP related to atmospheric/terrestrial/aquatic interactions (Church et al., 1989) are:

(1) to describe the regional variability of soil and watershed characteristics,

(2) to determine which soil and watershed characteristics are most strongly related to surface water chemistry,

(3) to estimate the relative importance of key watershed processes in moderating regional effects of acidic deposition, and

(4) to classify a sample of watersheds with regard to their response characteristics to inputs of acidic deposition and to extrapolate the results from this sample of watersheds to the study regions (Figure 1-1).

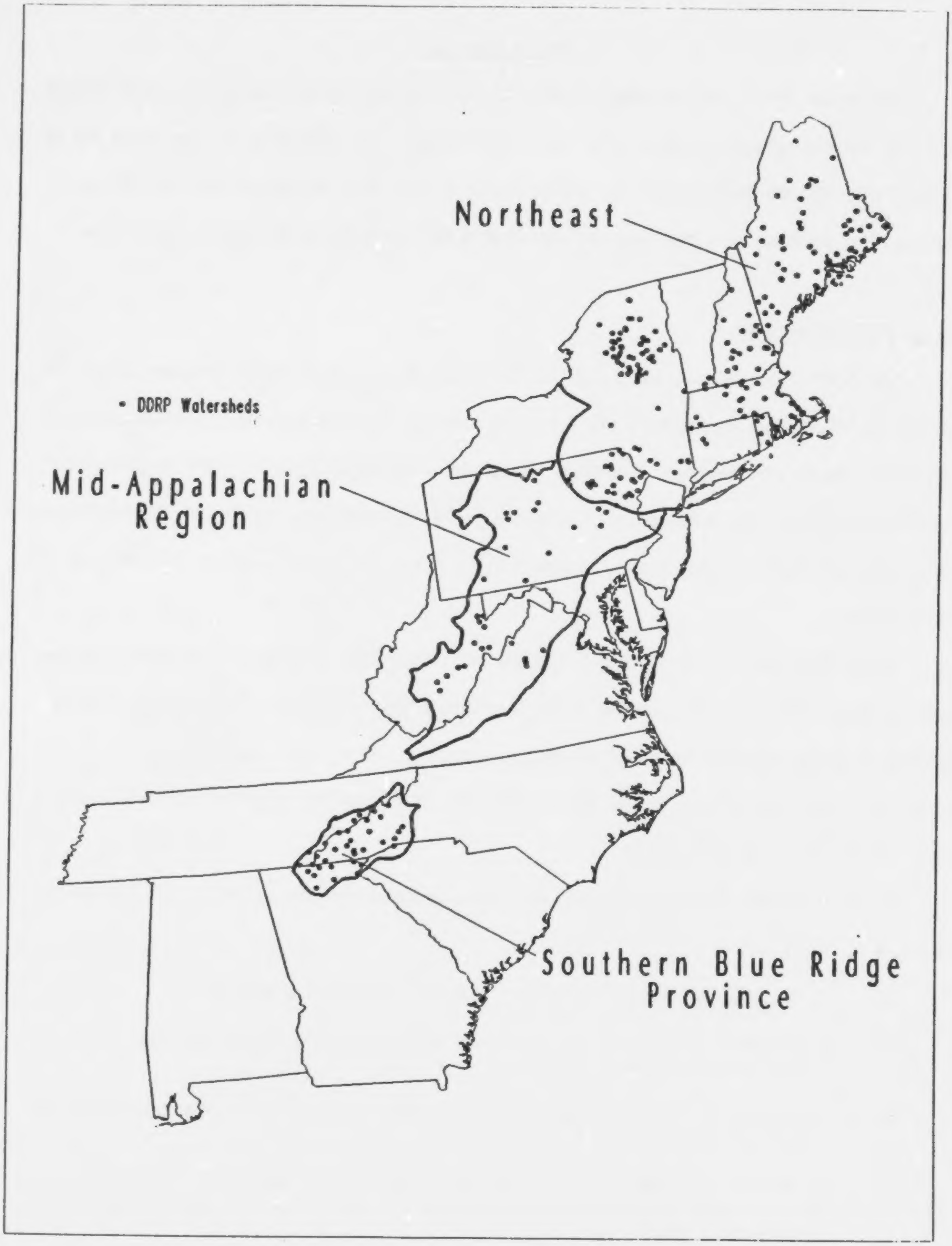

Northeast
• DDRP Watersheds
Mid-Appalachian Region
Southern Blue Ridge Province

Figure 1-1 Study Regions for the DDRP

WATERSHED SELECTION

The criteria for selecting watersheds for the DDRP are discussed by Church et al. (1989). The locations of the watersheds that were mapped are listed in Table 1-1. The watersheds chosen for characterization by the DDRP in the Mid-Appalachian soil survey were from Regions 2CN and 2BN of the Mid-Atlantic phase of the National Stream Survey (NSS) and some of the watersheds from Region 1D (Figure 1-2) of the NSS that met the following criteria:

1. watersheds of < 3,000 ha area;
2. acid neutralizing capacity (ANC) < 200 μeq/l; and,
3. minimal anthropogenic disturbances.

SOIL SURVEY DESIGN

The methods for DDRP soil survey activities are based on those of the US National Cooperative Soil Survey (NCSS) that are defined in the National Soils Handbook (Soil Survey Staff, 1983) and the guidelines for collecting soil samples and laboratory methods (Soil Survey Staff, 1984). The first phase of the DDRP Mid-Appalachian soil survey was the selection and mapping of the watersheds. The mapping activities produced soil, depth-to-bedrock, landuse, forest cover type, and drainage/water features maps. The Field Operations and QA Report for mapping in the Mid-Appalachian Region (Kern et al., 1990) documents the mapping and includes the mapping protocols and mapping QA plan. Sampling classes were developed using the mapping data (Lee et al., 1990). The DDRP soil sampling manual provides detailed information about the methods and is included as Appendix A. Sampling sites were randomly chosen using the soil maps. Protocols for sampling were revised from previous surveys and key personnel were given training. Sampling crews sampled the appropriate combination of sampling class and vegetation at the preselected sampling sites. The samples were sent to a soil preparation laboratory where preliminary analyses were conducted and the samples were assembled into batches with QA and quality control (QC) samples (Papp and Van Remortel, in press). The batches were shipped to contracted analytical laboratories where chemical and physical analyses were

Three increasingly complex levels of data analysis are being used for the assessment (Church et al., 1989): Level I - system description and statistical analysis; Level II - single factor response-time estimates; and, Level III - dynamic systems modeling.

Level I analyses include statistical procedures such as cumulative distribution functions, cluster analyses, or other multivariate procedures, and steady-state calculations such as sulfur input-output budgets, watershed indices, and equilibrium chemistry predictions. These analyses are being integrated with available data on watershed characteristics to correlate ranges of variables that influence long-term watershed response to sulfur deposition.

Level II analyses represent order-of-magnitude time estimates for the rate of change of important watershed responses (e.g., time to steady state sulfate adsorption). These analyses will be used to estimate the rate of change of individual processes theorized to be important in controlling surface water acidification.

In Level III analyses the dynamic watershed models used are the Model of Acidification of Groundwater in Catchments (MAGIC) (Cosby et al., 1985a; Cosby et al., 1985b; Cosby et al., 1986a; Cosby et al., 1986b), Integrated Lake-Watershed Acidification Study model (ILWAS) (Chen et al., 1983; Gherini et al., 1985), and Enhanced Trickle-Down (ETD) (Lee, 1987; Nikolaidis, 1987; Schnoor et al., 1986). The models integrate the key mechanisms controlling surface water chemistry, including soil contact, weathering, anion retention, and base cation buffering, and will be used to project changes in water chemistry in response to scenarios of long-term sulfur deposition.

The goal of the watershed surveys is to provide watershed and soil data for study regions in the DDRP. An overview of DDRP watershed survey activities is given by Lee et al. (1989) and the results of the DDRP research in the NE and SBRP are presented by Church et al. (1989).

The specific objectives of the DDRP soil surveys are to:

- characterize the variability of soil chemical and physical properties in watersheds of study regions, and
- provide data on other watershed characteristics (e.g., depth-to-bedrock, landuse, forest cover, drainage, water features and bedrock geology) across the study regions.

Table 1-1 Locations of the DDRP Mid-Appalachian Watersheds

ID Number	Watershed Name	State	Area (hectares)	Latitude (decimal degrees)	Longitude
1D029023	North Branch Rock Run	PA	1,217	41.5467	76.8711
1D029031	East Branch Wallis Run	PA	1,091	41.4381	76.8611
1D029042	Heberly Run	PA	1,673	41.3264	76.3469
1D029043	Bowman Creek	PA	1,967	41.3486	76.2067
1D036011	Stony Run	PA	539	40.8819	76.2344
1D036017	No Name	PA	1,305	40.7889	76.0644
1D037005	Jeans Run	PA	1,100	40.8728	75.7733
2B036028	Boyers Run	PA	407	40.6239	76.9522
2B036046	Lower Little Swatara Creek	PA	1,031	40.5525	76.2681
2B036062	Burns Creek	PA	1,868	40.2278	77.7153
2B041008	Piney Creek	PA	1,665	39.7936	78.4050
2B047032	Elk Run	WV	1,057	38.6319	79.5858
2B047036	Rible Run	VA	2,390	38.6444	79.0111
2B047066	No Name	VA	142	38.4053	78.2781
2B047076	Lewis Run	VA	315	38.3050	78.7458
2B047089	Moormans River	VA	1,717	38.1653	78.7447
2C028069	Whitney Run	PA	519	41.1283	78.5986
2C028070	Coldstream Run	PA	1,715	41.1128	78.3947
2C028075	Bear Run	PA	1,087	41.0150	78.5828
2C029002	Upper Dry Hollow	PA	1,085	41.6803	77.7753
2C029016	East Branch Big Run	PA	661	41.1961	77.7453
2C029020	Wolf Run	PA	2,255	41.0897	77.8686
2C035027	Williams Run	PA	1,947	40.4808	78.7717
2C041002	Fulton Run	PA	115	39.9428	79.4325
2C041039	Buffalo Creek	WV	580	39.2608	79.7550
2C041040	Thunderstruck Creek	WV	186	39.2486	79.6008
2C041045	Right Fork Clover Run	WV	1,976	39.1475	79.7150
2C041051	Coal Run	WV	503	39.0397	79.6164
2C046005	No Name	WV	75	38.6856	80.5522
2C046033	Johnson Run	WV	427	30.0472	80.4081
2C046034	Hateful Run	WV	154	38.3511	80.2586
2C046041	No Name	WV	251	38.2211	80.7153
2C046050	Hendricks Creek	WV	51	38.1253	80.9822
2C047007	Crawford Run	WV	351	38.7589	79.9233
2C047010	Clubhouse Run	WV	781	38.6322	79.7605
2C057004	Butler Branch	WV	313	37.9561	80.9428

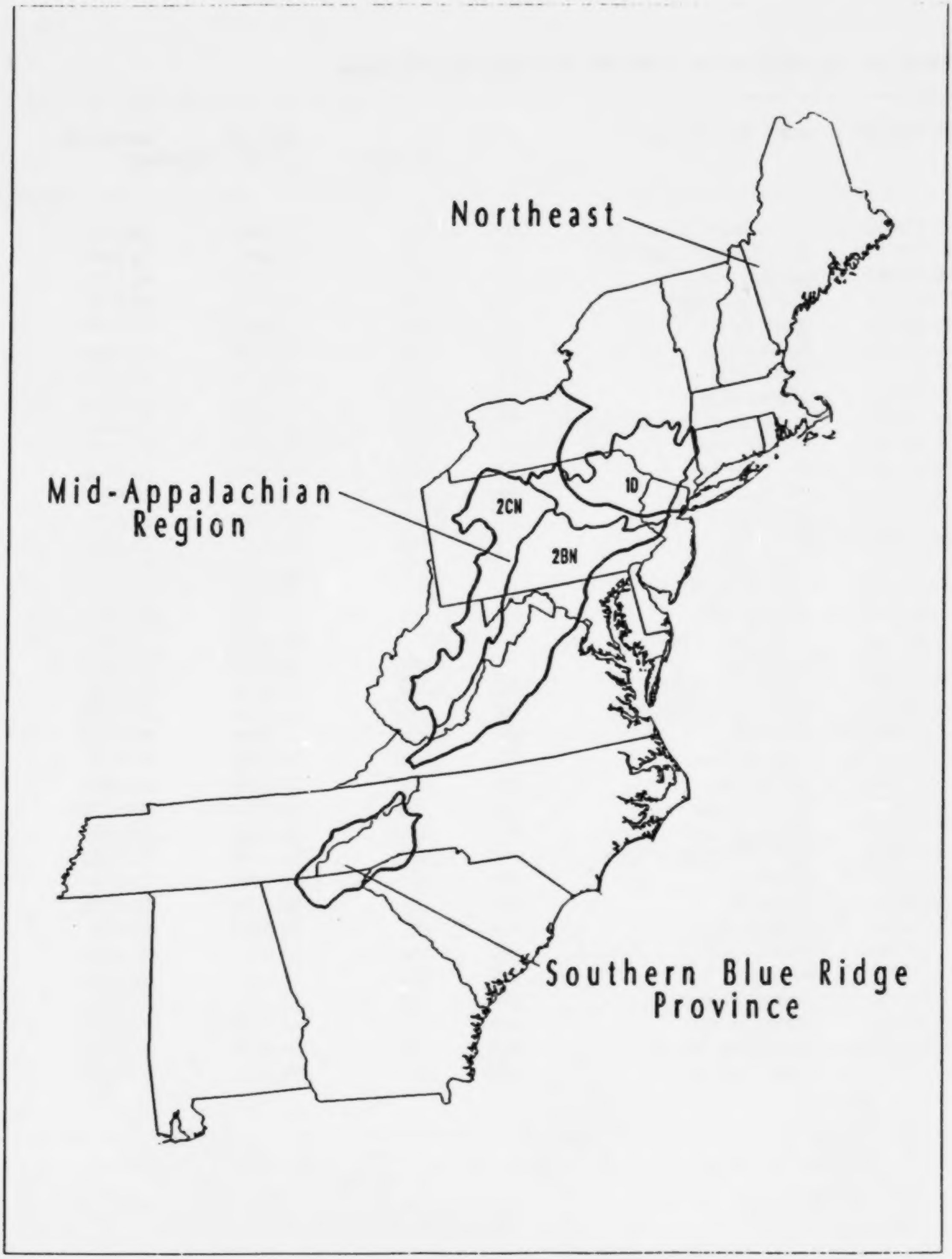

Northeast
Mid-Appalachian Region
2CN
1D
2BN
Southern Blue Ridge Province

Figure 1-2 Subregions of the National Stream Survey

conducted. The results for the QA/QC samples were evaluated to determine whether the data were acceptable (details are presented in the QA plan for the analytical analyses [Papp et al., 1989]).

Project Organization and Personnel

The soil sampling for the DDRP Mid-Appalachian survey was managed by ERL-C. Logistical support and QA program assistance was provided by the USEPA Environmental Monitoring Systems Laboratory - Las Vegas, NV (EMSL-LV). The Sampling Task Leader from ERL-C had overall responsibility for the sampling activities. The DDRP Soils QA Coordinator from ERL-C had the primary responsibility for revising the protocols, training, conducting audits, and the preparation of this Field Operations and QA Report.

The soil sampling crews were US Department of Agriculture - Soil Conservation Service (SCS) personnel. Each of the soil sampling crews was supervised by a crew leader who was a soil scientist experienced in NCSS procedures. The crew leaders had the primary responsibility for site selection, profile description, documentation, the collection of representative samples that were free of contamination, proper storage and shipment of samples, reporting any difficulties to the Sampling Task Leader, and for returning unused equipment to the USEPA.

The SCS State Soils Staffs (SSS) for PA and WV were responsible for the assignment and supervision of crews, for conducting a field methods evaluation at least once per crew including an independent profile description, for reviewing all site and soil profile descriptions, and for returning supplies and equipment to the USEPA at the completion of sampling.

The Regional Coordinator/Correlator (RCC) was a private contractor to the USEPA who had extensive experience in soil profile description, mapping, and sampling. The RCC visited one site for each of the original field crews to assess adherence to the protocols and to prepare an independent profile description.

Sampling Classes

The map unit components in the sampling region were too numerous to allow sampling each one. The approach used in the DDRP is to group soils that have similar properties that would cause them to interact with acidic deposition in similar ways. Soil characteristics that were considered most important were particle size distribution, mineralogy (including whether soils are organic or mineral), drainage class, depth to bedrock, and depth to impermeable layers. Soils were grouped into 15 sampling classes during a soil correlation workshop (Figure 1-3). A more detailed discussion of sampling classes is presented by Lee et al. (1990).

There were two watersheds in VA (2B047066 - No Name and 2B047089 - Moormans River) with igneous and metamorphic bedrock rather than the sedimentary bedrock found in the other watersheds. DDRP scientists decided to place the pedons sampled on these watersheds in the special sampling classes presented in Table 1-2.

Selection of Potential Sampling Sites

The resources of the project allowed the sampling of 150 pedons. Four pedons were reserved for each of the two non-sedimentary bedrock watersheds mentioned above. Map units that were eligible for sampling had at least 20 percent of the desired sampling class. There were a total of 158 occurrences of eligible map units. The selection of occurrences for sampling were made according to the following principles:

- Samples should be allocated over sampling class proportional to frequency of occurrence, with at least eight samples per sampling class. (Eight pedons were sampled for most classes in the DDRP NE and SBRP surveys.)
- Fewer pedons should be allocated to mine soils (CMS) and organic soils (HST) classes. All occurrences should be selected for at least one sample.
- Within sampling class, samples should be allocated over watersheds in proportion to the occurrence of the area of the sampling class on the watershed.
- At least two samples should be collected from all watersheds.

The QA plan (Appendix B) presents more details about the number of occurrences of map units on watersheds and their locations. After a watershed was selected for sampling of a particular sampling class, all delineations of map units having at least 20 percent of the area in that class were colored on a photocopy of the soil map. A dot grid was randomly placed over the soil map, and the dots that fell on a colored area were numbered. Five starting points were then randomly selected

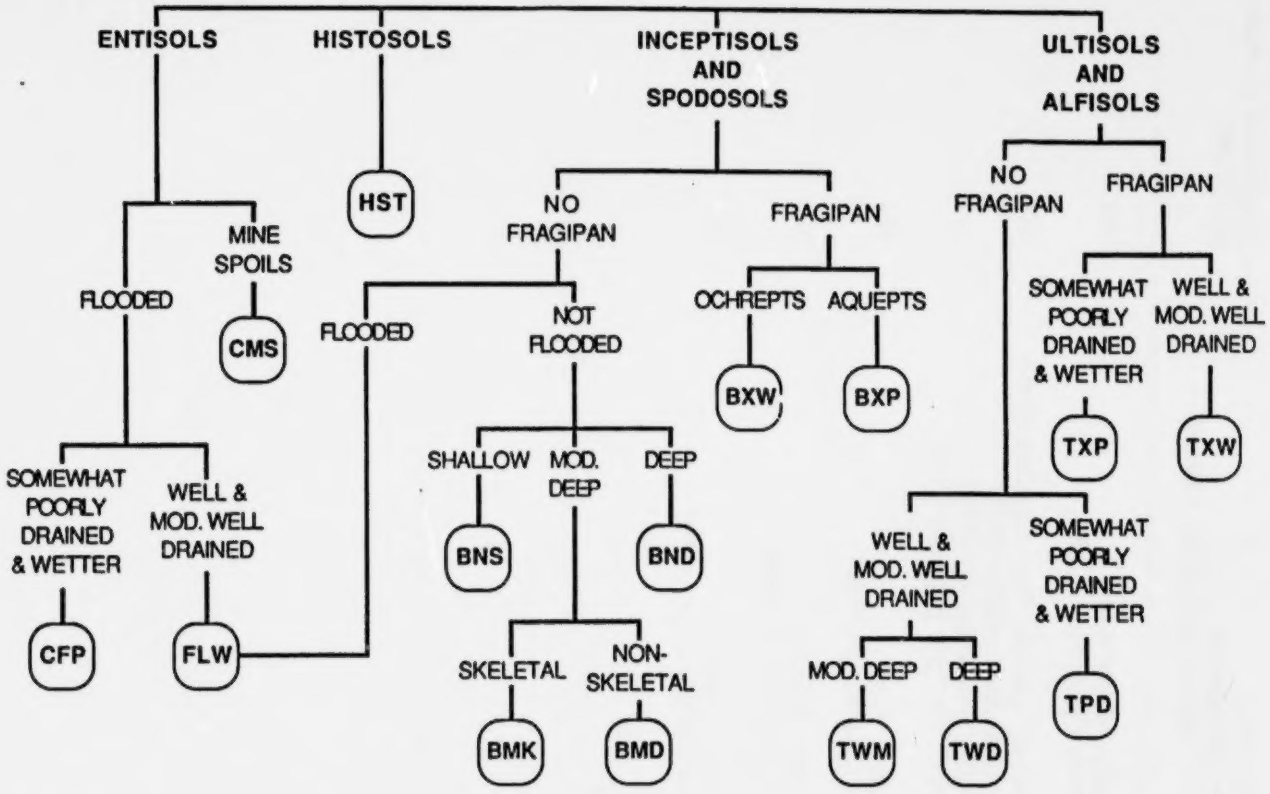

ENTISOLS
HISTOSOLS
INCEPTISOLS AND SPODOSOLS
ULTISOLS AND ALFISOLS
FLOODED
MINE SPOILS
CMS
SOMEWHAT POORLY DRAINED & WETTER
WELL & MOD. WELL DRAINED
CFP
FLW
HST
NO FRAGIPAN
FRAGIPAN
FLOODED
NOT FLOODED
SHALLOW
MOD. DEEP
DEEP
BNS
BND
SKELETAL
NON-SKELETAL
BMK
BMD
OCHREPTS
AQUEPTS
BXW
BXP
NO FRAGIPAN
FRAGIPAN
SOMEWHAT POORLY DRAINED & WETTER
WELL & MOD. WELL DRAINED
TXP
TXW
WELL & MOD. WELL DRAINED
SOMEWHAT POORLY DRAINED & WETTER
MOD. DEEP
DEEP
TWM
TWD
TPD

Figure 1-3 Sampling Class Flowchart for the DDRP Mid-Appalachian Survey

Table 1-2 Sampling Classes for Two Non-Sedimentary Bedrock Watersheds

Sampling Class	Composition series, classification (sampling class on sedimentary bedrock)	Areal Extent (% area)	
		2B0477066	B047089
VA1	1 pedon. Codorus tax, Fluventic Dystrochrept (CFP)	10.5	0
VA2	4 pedons. Lew tax., Typic Hapludult (TWM) Myersville, Ultic Hapludult (TWD) Eubanks, Typic Hapludult (TWD) Eubanks tax, Typic Hapludult (TWD)	48.6	37.5
VA3	1 pedon. Ashe, Typic Dystrochrept (BMD)	40.9	0
VA4	1 pedon. Cataska, Typic Dystrochrept (BMK)	0	37.4
VA5	1 pedon. Catoctin, Ruptic-alfic Eutrochrept (BMK)	0	23.5
Miscellaneous areas:			
Rubble land		0	0.02
Rock outcrop		0	1.6

from these numbered dots. The first point that was selected became starting point one. The starting point closest to point one became starting point 2, the next closest point 3, and so on.

A modification of this procedure was used to prevent over-representation of map units with less than 60 percent of the desired class. Let x equal the percent of the area of the map unit in the class. Then, if a starting point fell within a delineation of the map unit, a number between 1 and 100, y, was randomly selected. If y is less than x, the starting point was kept; otherwise, it was dropped and another random point selected.

After the five starting points were selected, the vegetation map overlay was used to determine the vegetation expected at those points. A broad vegetation class was specified for each point by classifying the expected vegetation as hardwoods, conifers, mixed hardwood and conifer, pasture/ grassland, crops, or urban - not forested.

A different procedure was used for watersheds 2B047066 and 2B047089. DDRP scientists designated sampling sites on soil maps based on proximity to the streams and abundance of that soil on the watershed. Sampling crews were then instructed to sample a soil at each site that was representative of soils in that part of the watershed.

FIELD PROCEDURES

The procedures summarized below are presented in detail in the sampling protocols that are included as Appendix A.

Selection of Actual Pedon Sampling Sites

Pedons were selected using the procedures in the protocols for locating random sites within pre-selected areas, except for watersheds 2B047066 and 2B047089. The pedons selected for sampling were intended to represent the sampling class chosen for sampling and not necessarily a particular soil series. The NCSS and other soil surveys commonly sample pedons chosen to represent the central concept of a particular soil series. The approach in the Mid-Appalachian survey was to obtain randomly located samples to characterize the sampling class across the region. This avoided possible individual bias about what is the central concept of a series. The sampling sites were required to conform to a preselected vegetation class.

The soil sampling crews were provided a map for each pedon to be sampled with five numbered points delineated. The steps involved in site selection are summarized from the protocols (Appendix A). The sampling crew went to the numbered points, in sequence, using the site selection procedure until the combination of sampling class and vegetation was encountered. The site selection procedure specified that the sampling crew locate the first starting point. If the appropriate soil/vegetation sampling class were present then they would sample the pedon. If not, 1 of 8 compass points was selected using a random-number table, then sites were evaluated along the compass bearing until the proper soil/vegetation sampling class was located (for 150 m in 10 m increments) or until the crew was clearly out of the area of the selected sampling class. The crew made five such transects (or fewer if it was clear that the proper sampling class/vegetation could not be found) and, if unsuccessful, went to the next numbered point. There were no cases where a suitable combination of sampling class and vegetation could not be found for all five potential sampling points.

Pit Excavation

The sampling sites were excavated to at least 1 m wide and 2 m deep or to bedrock or other impediment. Histosols could not be excavated with conventional soil pits and were sampled using augers and/or shovels. Some pedons could not be sampled to a two meter depth because of many rock fragments, high watertables, or unstable excavations. Most of the pits were dug by hand but some were dug using a backhoe.

Site and Soil Profile Description

The purpose of the site and soil descriptions is to provide information about the local and regional physiography, geology, drainage, landuse, soil classification, vegetation, and characteristics of the soil horizons using standard terminology. The forms for this survey are based on the SCS 232-form which is designed for standard NCSS terminology with codes for easy entry into a computer (Appendix A). The guidelines for making site and soil descriptions, and a glossary of geologic terms are presented in the National Soils Handbook (Soil Survey Staff, 1983). Soil Taxonomy (Soil Survey Staff, 1975; 1988) is the soil classification system used by the NCSS and this survey. The descriptions are particularly important for the DDRP because they provide horizon designations, horizon depths, rock fragment content, and the field measured volume for calculation of bulk density using the new methods.

Horizons greater than 30 cm thick in the upper 1 m were split for sampling and were subdivided in the description. The horizon designations were identical for the split horizons except that they were consecutively numbered (e.g., Bt1, Bt2). Uniform horizons greater than 60 cm thick below 1 m were also split for sampling and separated in the description. This provided each subdivision with a unique horizon number on the profile description form.

Photographic Documentation

Photographic documentation is important for future reference should any questions arise about site location, vegetation, or profile characteristics. The pedon face, tree canopy (if present) above the face, understory vegetation, and landscape were photographed with fully automatic 35 mm cameras with built-in flash units using ASA 200 color slide film. The pictures were identified by a photogray card included in the pedon face picture and the frame numbers were recorded in the logbook. Horizons were marked with white golf tees at horizon boundaries and with a tape for scale. Histosols were photographed by reconstructing profiles on sheets of plastic.

Sampling

Bulk Soil Sampling–

All horizons greater than three centimeters in thickness were to be sampled. Horizons thinner than three centimeters were not practical to sample without contamination from adjacent horizons. Thick horizons, as discussed above, were subdivided for sampling. Samples were taken from throughout horizons to yield representative samples. Horizons with thin strata or distinct portions of contrasting material were sampled in proportion to their abundance in the field. Forest litter layers (Oi horizons) were not sampled.

Bulk samples were obtained that yielded at least 2 kg of air dried soil that passes a 2 mm sieve. The soil was sieved through a 20 mm sieve into a 3.5 L bucket in the field. If the volume of the rock fragments that passed the 20 mm sieve exceeded 45 percent, an additional 3.5 L of sample was required for each additional 10 percent rock fragments. Roots and wood fragments were removed from samples. The sieved soil was placed in plastic bags, adhesive labels were placed on them, and they were placed in labeled canvass bags. Two full 3.5 L sample bags of organic material were requested.

Quality Control Samples--

Samples used to assess possible sampling bias and sample contamination were handled every third pedon sampled. Field duplicates were duplicate samples of one horizon as identical to the routine bulk sample as possible. Field duplicates were obtained by placing alternate trowelfulls of soil from the horizon into two different sample bags. Field duplicates provide a measure of the precision of the sample. Field duplicates were not sampled by obtaining a large amount of soil, homogenizing it, and dividing it because of the possibility of contamination while mixing the sample. The field duplicates were sieved and bagged the same way as routine samples.

The same day that crews sampled field duplicates they carried into the field three 500 g bags of soil provided to them by the USEPA. These field audit samples were designed to assess contamination introduced while sieving, bagging, and transporting samples. The first field audit sample was sieved and bagged after sampling the first horizon, the second after a horizon mid-way in the profile, and the last after the last horizon was sampled. The field audit samples are well mixed portions of previously characterized soil. If the analytical results for field audits were significantly different than the previous results it would have suggested that sample contamination had taken place. If other audit samples that were shipped with a potentially contaminated audit sample did not show contamination then contamination during sampling activities would be suspected. Contamination, as evidenced by anomalous pH and/or percent organic matter content, was evaluated by the preparation laboratory while continuing sampling activities were in progress.

Bulk Density Samples--

Bulk density is a measure of the mass of fine (< 2 mm) soil material per unit volume which is important for converting measurements made on a weight-basis to a volume-basis. The preferred method for this survey was that soil scientists attempt to use the clod method (Soil Survey Staff, 1984). The clod method was the only method used in previous DDRP surveys. If clods could not be obtained, the volume-replacement method was used. If the volume-replacement method was not possible, the volume-fill method was used (Kern and Lee, 1989). The goal was to obtain bulk density measurements for every horizon that was sampled.

Clod samples were intact soil aggregates that were placed in hairnets and dipped into a saran mixture. The volume of the clods was obtained at the preparation laboratory using Archimedes' Principle of volume displacement and the fine soil material was weighed. Soil scientists sampled clods that were 200 to 400 cm^3 if possible. Protruding pieces and roots were trimmed from clods. Clod samples could not be obtained from very friable and loose horizons, and horizons with abundant roots or rock fragments. Three clod replicate samples were obtained whenever possible.

The volume-replacement and volume-fill methods were developed by the DDRP for use when clods could not be obtained (Kern and Lee, 1989). In the volume-replacement method, a level step was prepared in the horizon. Soil was sampled from a roughly circular hole (approximately 1 cm in diameter and 10 cm deep or to the boundary of the next lowest horizon), and the hole was lined with cheesecloth. The volume of the hole was measured using lightweight plastic beads and a graduated cylinder (2 L, graduated to 10 mL). A straight-edge was placed across the hole as a guide for filling the hole with beads which were fiber reinforced epoxy with an average diameter of 6.3 mm and a range of 3.2 to 9.5 mm. Plugs were made for each graduated cylinder to enable direct reading of volume from the bottom of the plug. Two replicate samples were obtained for each horizon where possible. The volume of the excavation is the difference between the volume of the beads in the cylinder before and after filling the hole. The mass of the excavated soil and rock fragments were determined in a laboratory. Advantages of this method are that the beads are lightweight (unlike sand or water used with similar methods), and the method does not require heavy and bulky equipment used with sand or bead cones. The disadvantages are that it is time consuming to do carefully, it is difficult to level thin surface horizons, horizons with abundant roots or rock fragments, the beads float in water of wet horizons, and leveling the beads in the excavation can be difficult.

In the volume-fill method, soil was packed into a container of known volume (approximately 250 cm^3) in an attempt to re-create natural packing. The soil was then transferred to a bag. The mass of the excavated soil and rock fragments were determined in a laboratory. Two replicate samples were obtained for each horizon where possible. Advantages of this method are that it requires very little equipment, it is easy and fast to do in the field, and because the packing is done in the field it is possible to compare with undisturbed soil. Disadvantages are that it is difficult to pack without voids where coarse-fragment content is high, the natural structure of dense horizons is disrupted and may be hard to re-create in the container, and judging how to re-create the natural packing may be subjective.

Sample Transportation, Storage, and Shipment

Clods are extremely fragile and were placed in compartmentalized boxes with padding for transport. Other samples were transported out of the field carried by hand or in backpacks. Samples were transported in trucks or cars. Care was taken to ensure samples would not be contaminated or become excessively hot or cold.

Routine and QC samples had to be placed in cold (4°C) storage if they were not shipped to the laboratory immediately. The best way to do this was to place them in refrigerators, but it was acceptable to store them in foam coolers with two frozen gel packs. Care was taken to ensure that samples were not frozen. The purpose of cold storage was to ensure careful storage and handling of the samples and to minimize the mineralization of organic matter.

Samples were transported to a preparation laboratory in Las Vegas, NV, by overnight carrier. Routine and QC samples were shipped in foam coolers with two frozen gel packs. Copies of the transportation log from the crew logbook and the original site and soil description forms (232-form) were included with each shipment. Copies of the 232-forms and the sampling site location map with the final sampling point marked were sent to the Sampling Task Leader at ERL-C.

2 FIELD OPERATIONS

PREPARATION FOR FIELD OPERATIONS

Development of Protocols

The soil sampling protocols from previous DDRP soil surveys (Blume et al., 1987a; 1987b) and the guidelines of the NCSS (Soil Survey Staff, 1984) were the basis for the revised sampling protocols (Appendix A). The revised soil sampling protocols used the same general approach as the previous DDRP sampling activities, but were updated to include new bulk density methods, a new type of QC sample, different requirements for frequency of field duplicates, and a new standardized logbook that was recommended by Coffey et al. (1987a; 1987b). The DDRP site selection procedures are unique to this project and are not used by the NCSS.

Preparation Laboratory

In previous DDRP soil surveys, representatives of crews delivered their samples to regional preparation laboratories. The sampling sites for this survey were geographically widespread and remote which would have made delivery of samples by the crews time consuming. The cost and time for having crews deliver their own samples justified shipping all of the samples by overnight carrier to one central preparation laboratory. A laboratory in Las Vegas, NV, was established by EMSL-LV to dry, sieve, subsample, and ship samples to laboratories contracted to conduct physical and chemical analyses. The preparation laboratory also measured field moist pH to check for possible carbonate content, percent organic matter content by loss-on-ignition to determine if samples should be analyzed as mineral or organic, and bulk density. Samples were sent to the preparation laboratory in coolers with frozen gel packs to maintain sample integrity. The preparation laboratory was responsible for procuring and distributing most of the field sampling equipment. A complete list of field equipment provided to crews is given in the protocols in Appendix A. The operations and methods of the preparation laboratory are presented in Papp and Van Remortel (in press).

Contracting Sampling Personnel

Interagency agreements were established between the SCS and the USEPA to provide personnel to conduct the sampling because the SCS maintains a staff of qualified soil scientists in the geographical area of interest. The SCS is the lead federal agency for the NCSS with considerable experience in soil mapping, description, and sampling. The SSSs from PA and WV were responsible for supervising the personnel from their states and conducting audits of them. The same soil scientist who had been the RCC for the DDRP original and additional Northeast, and the Mid-Appalachian mapping was contracted to be the RCC for sampling.

Pilot Soil Sampling

During the first week of August 1988, the revised sampling protocols, new bulk density methods, equipment, and shipping procedures were tested by the Sampling Task Leader and the ERL-C DDRP Soils QA Coordinator in a DDRP watershed in WV. The protocols were closely followed to evaluate if there were ambiguous or misleading instructions. The preparation laboratory shipped a set of sampling equipment to a nearby SCS office to evaluate if there would be any problems shipping supplies.

It was immediately evident that there was a problem with the shipped saran for clods. The solution arrived with solidified masses in it that resembled seaweed. It was not possible to ascertain what caused the solution to solidify, so it was recommended that bags of powdered saran be sent to crews with acetone for crews to prepare the mixture on site. Site selection, bulk soil, and duplicate sampling procedures were evaluated and found to be acceptable. Clods could not be sampled from all horizons because of loose consistence, rock fragments, and root content. The new bulk density methods worked well in the field. The instructions in the protocols were clarified by going through them set by step. Plastic buckets were bought locally that were 3.5 L which fit the 20 mm sieves. A sample was shipped to the preparation laboratory that had not been sieved which was successfully detected by the laboratory.

Sampling Crew Training

The Sampling Training Workshop was held September 7 and 8, 1988, in State College, PA, and was directed by the ERL-C DDRP Soils QA Coordinator. All of the key personnel involved in the sampling went to the workshop. Participants were given the final draft of the sampling protocols and some sampling equipment. The workshop focused on presenting and explaining the requirements of the protocols. The site selection and labeling procedures were discussed in detail. The new bulk density methods were demonstrated in the field and general sampling techniques discussed. The final version of the sampling manual was sent to the crews during the first week of sampling.

SOIL SAMPLING

The fieldwork for the sampling took place from September 14 to December 20, 1988 (Table 2-1). The preparation laboratory staff had estimated that, in order to meet the sample shipment schedule to the analytical laboratories, the last shipments from the sampling crews needed to be received by the first week of December. The sampling took slightly longer than expected because of the remoteness and wide physical separation of the watersheds, and because the summer and fall of 1988 were drier than normal, making it harder to auger or excavate some soils. This did not adversely impact the sample processing at the preparation laboratory because the laboratory was ahead of schedule.

Sampling Equipment

The crews were kept adequately stocked with equipment and contacted the preparation laboratory directly to procure additional equipment. Foam coolers were sent out to the crews at the beginning of the project. Coolers were returned to the crews on a regular basis because most of the crews did not have large storage areas. There were times when the crews had to wait for new shipments of supplies but this was not frequent and did not interrupt the scheduling of the sampling. The crews used the pumps to pump out wet excavations, but the outlet hose provided on the pump was not long enough to accommodate the 2.0 m excavations specified in the protocols.

Table 2-1 Summary of Soil Sampling Activities

Crew Number	Number of Pedons Sampled		Beginning Date, 1988	Ending Date, 1988
PA01	36		9/14	12/14
PA02	41		9/15	12/9
PA03	18		10/18	12/20
WV01	23		9/27	11/10
WV02	32		9/15	10/26
Total	150	All Sampling:	9/14	12/20

Site Selection

The site selection procedure employed a different approach than that to which the soil scientists were accustomed. The concept was to obtain a randomly located pedon within the area that the particular sampling class was mapped. Pedon series identification was not critical because of the requirement that a pedon meet the criteria for a particular DDRP sampling class, not soil series.

Site Restrictions--

There were no cases where a pedon could not be located for sampling because of site restrictions at all of the potential sampling points. Some sites could not have evaluation for sampling sites because either permission was denied for access, or landowners could not be contacted. In one case, a landowner wanted to accompany a crew on their property and he could not be present during the time needed by the crew (PA107004). One field was inaccessible during site selection for PA055002 because there was unharvested corn. There were too may surface stones to allow excavation to sample PA055006 at one site.

Sampling Classes--

There was only one instance where a pedon (WV067001) was sampled that did not fit the preselected sampling class. It was sampled as TPD, but it was moderately well drained making it TWD. There were some cases where the placement of soils into sampling classes was not straightforward. These situations included identification of argillic horizons, fragipans, drainage class, family textural class, and flooding frequency.

Argillic horizons have evidence that there has been significant amount of clay movement into the horizon. Field criteria for argillic horizon identification are a 3 to 8 percent increase in clay (depending on clay content) from the overlying horizon and clay coatings on aggregates that are called clay films or cutans (Soil Survey Staff, 1975). Identification of argillic horizons is not always easy in the field because clay increase might be the result of uneven clay distribution in the parent material and not illuviation (clay movement into the horizon). Particle size analysis in the laboratory, including the determination of the fine-clay fraction, may be required to conclusively determine movement of clay. Cutans, or coating resembling cutans, may be a relic of the parent material. Microscopic study of soil thin sections to determine the orientation and continuity of clay films is often necessary to conclusively identify argillic horizons. Some cases are inconclusive even with detailed particle size analysis and micromorphological study. Spatially, there may be a mix of soils with argillic, borderline argillic, and non-argillic properties. Clay movement is considered an indication of the stage and type of soil development.

The DDRP sampling classes for this survey use the absence or presence of argillic horizons as a major criterion because this is one of the criteria that separates Inceptisols/Spodosols and Entisols from Utisols/Alfisols. Spodosols were grouped with Inceptisols because they are relatively rare in the DDRP Mid-Appalachian watersheds. The Spodosols were expected to have similar particle size distribution and mineralogy to the Inceptisols. The sampling classes were designed to classify the soils mapped in the DDRP watersheds. There are Spodosols with argillic horizons that are called Alfic Haplaquods (Soil Survey Staff, 1975), but they are not found in the DDRP Mid-Appalachian watersheds. There were some soils mapped in the watersheds as Inceptisols with intermittent argillic horizons (Ruptic-Alfic Eutrochrepts), but they did not have enough argillic development to make them Alfisols.

There may be some cases where Alfisols with weakly developed argillic horizons will closely resemble Inceptisols that are at the stage of development where there has been some clay movement. Table 2-2 lists the identity of pedons with borderline argillic development. There was one case where a crew reported disqualifying a potential sampling point because the argillic development was too deep for the particular soil series. The crew moved to another point where they found a suitable soil, but the first point would have been an appropriate sample because the depth of the argillic was not a factor in the identification DDRP sampling classes.

Table 2-2 Pedons Reported to Have Borderline Argillic Development

Pedon ID	Sample Class	Comments
PA081008	BXW	Borderline to TXW
PA081009	BXW	Borderline to TXW

The presence or absence fragipans is a similar that is at the next lower level in the sampling class flowchart than the argillic criteria for sampling classes of Inceptisols/Spodosols and Ultisols/Alfisols. Fragipans are dense horizons that have formed as the result of soil forming processes and are not inherited from the geologic parent material, such as dense basal glacial till. Fragipans were recognized as separate classes in the DDRP sampling scheme because they have a great influence on water movement in soils. Fragipans are dense but brittle. The denseness is due to close packing of the soil particles rather than cementation (although, there may be some weak cementation). A problem in the field identification of fragipans in this study is determining what criteria and the amount of expression of fragipan development that qualifies a horizon to be a fragipan. There is no specific laboratory test for fragipans and there is no single identifying characteristic. There is usually an elluviated horizon above the fragipan. Fragipans usually have prismatic structure, a brittle matrix, and air dry samples slake if placed in water. The brittleness and evidence of root restriction are often key factors in identifying fragipans (Soil Survey Staff, 1975). There was one pedon reported to have borderline fragipan development (Table 2-3).

Table 2-3 Pedon Reported to Have Borderline Fragipan Development

Pedon ID	Sample Class	Comments
PA107007	BND	Has some dense characteristics and is almost a BXW

Drainage class was used as a distinguishing criterion for all of the sampling classes except for Histosols. The distinction between somewhat poorly drained and wetter versus moderately well drained and better drained. The PA SSS reported in one of their audit reports that some of the soils sampled as TPD, TXP, and CFP were somewhat poorly drained soils that were borderline to being moderately well drained soils. Such soils might have similar properties to the corresponding better drained soils.

Table 2-4 Pedons Reported to Have Borderline Drainage Classes

Pedon ID	Sampled As	Borderline To	Comments
PA033007	TXP	TXW	Borderline moderately well to somewhat poorly drained. Low chroma mottles are above the fragipan.
PA009002	BND	–	The sampling crew called it well drained, but an independent evaluator thought the manganese ped coats were an indicator of wetness. There were no low chroma colors described and wetness is not a diagnostic criteria for this sampling class so no change was made.
WV067001	TPD	TWM	There are low chroma mottles, but they are deep enough in the profile that the soil is borderline somewhat poorly to moderately well drained.
WV101001	TPD	TWM	There are low chroma mottles in the BC horizon, but they are deep enough in the profile that the soil is borderline somewhat poorly to moderately well drained.

Family textural class, as defined by Soil Taxonomy (Soil Survey Staff, 1975), is only a sampling class criteria between BMK and BMD. These two sampling classes consist of Inceptisols and Spodosols that do not have fragipans, are not subject to flooding, and are moderately deep. The difference is that BMK soils are skeletal and the particle size control section averages more than 35 percent rock fragments by volume. Borderline situations were problematic and require the sampling crew to consider the rock fragment content of the surrounding polypedons rather than only the pedon being sampled. Crews estimated the rock fragments in the pedon exposed in their pit and assessed this with what they could see about surrounding pedons. To take into account the possibility of bias introduced when summing several estimates of the various rock fragment classes, the DDRP criteria was that if the weighted average fell plus or minus five percent of the class designated by the crew, then it was considered acceptable. This occurred for one pedon (PA081010) that averaged 39 percent rock fragments using the crew's estimates. The crew leader was contacted and he felt certain that the excavated pedon was non-skeletal. The crew leader adjusted the estimates which resulted in 34 percent average rock fragment content.

One question arose because the sampling class guidance did not specify exactly what was meant by flooded. There were two pedons (VA165005 and VA165007), sampled as FLW, that were described on floodplains, but were rarely to very rarely flooded. The assignment of sampling classes as FLW is appropriate because the parent material is alluvium and there is some, although rare, deposition and erosion caused by flooding.

Vegetation Class Considerations–

The sampling crews had some minor misunderstandings about the vegetation class requirements. The protocols stated that a crew should sample only where the vegetation of the site matched the preselected vegetation. The field audits identified a three cases where the crew did not follow the protocols. In one situation a crew sampled a pedon where the vegetation did not match the preselected vegetation because the next numbered site had the same vegetation. Pedon PA00902 was preselected as open by USEPA, but the crew sampled it as hardwood because all of the other starting points were listed as hardwood. There was a situation (PA009003) where the pedon was located on the boundary between two vegetation delineations and the crew sampled an open area although it was listed by USEPA as conifer. The vegetation for WV083004 was deemed mismapped by the sampling crew and they sampled a hardwood site mapped as pasture. These situations were identified early in the sampling project and crews were requested to sample only when the preselected vegetation matched the site.

Pedon Excavation

Pedon excavation, as in previous DDRP surveys, was difficult in poorly drained mineral and organic soils. Slumping due to incoming water flow commonly prevented such soils being excavated to 2 m. Organic soils could not be excavated and were sampled with augers. As was mentioned previously, the pumps did not have long enough outlet hoses to effectively pump down to a 2 m depth. Even when the hose would reach, it was often difficult to pump the water out as fast as it was coming in. Despite filters, the pumps would sometimes clog with fine sediment. Pedon excavation, even with a backhoe, was difficult in soils with a high rock fragment content. This was most common in floodplain and mine soils. Pedons with strongly expressed fragipans or with abundant surface rock content were also difficult to excavate.

Site and Soil Profile Description

The soil scientists quickly became accustomed to using the computer coded site and soil profile description form. Minor confusion occurred at the beginning of the project when some crews thought that they were required to put a dash in all unused fields. The forms and codes were adequate for describers to record their observations. There were not explicit instructions to the crews about how to structure the horizon notes and miscellaneous free-form notes. Data entry would have been easier and more uniform if all the crews had recorded the free-form notes in the same format. There were instances where notes about the general condition of pedons were entered in the notes for individual horizons.

Photographic Documentation

The quality of the slides taken was exceptionally good. The cameras provided had built in flashes and automatic light meters which gave clear and well exposed pictures. The crews were asked to always use ASA 200 film to account for dimly lighted situations, but it was not always available locally. Film should have been supplied by the preparation laboratory rather than purchasing it locally because of the difficulty of buying high speed slide film in rural towns. The pedons without photographic documentation are listed in Table 2-5.

Table 2-5 Pedons Without Photographic Documentation

Pedon ID	Reason
PA009004 PA009005	The roll of film was destroyed by the processing laboratory due to what the laboratory called an "unusual lab circumstance".
WV075003 WV075004 WV075005	The roll of film was dropped into water by the sampling crew. Several processing laboratories were consulted, but none of them could process the film.
WV019007	The sampling crew ran out of film while out in the field.

Bulk Sampling

There were several types of situations where bulk-samples were difficult or impossible to obtain. The forest litter layer (Oi horizons) was not considered soil material in this study and was not sampled. The organic layers below the litter layer in forested sites were typically a combination of moderately decomposed and highly decomposed (Oe and Oa horizons) organic material. These horizons were often too thin (< 5 cm thick) to sample. It was often difficult to obtain the required two 3.5 L samples even when the horizons were greater than 5 cm thick. It was difficult to obtain bulk samples when there was a large rock fragment content. If a large amount of rock fragments passed a 20 mm sieve then more than 3.5 L of sample were required to be collected. The difficulties of excavating wet soils, discussed above, made it difficult to obtain bulk-samples. Special care was needed when sampling with an auger to obtain samples from the appropriate depth and to avoid mixing material from more than one horizon. The rock fragments in some of the horizons had weathered to the point where they broke up into smaller fragments (i.e., sand, silt, and clay) when sieved. This was noted on some of the description forms and the preparation laboratory handled these samples gently to prevent changing the particle size distribution.

Possible Sample Contamination–

Samples that have potential contamination are listed in Table 2-5. Pedon VA165005, that was sampled in an area contaminated by agricultural wastes, had significantly different values than other pedon/horizon combinations for the same sampling class for Na and K exchangeable by NH_4Cl and $CaCl_2$, and for SO_4 extractable by H_2O and NaH_2PO_4. The field duplicate for PA1050002 had anomalous values for Ca exchangeable by NH_4OAc and $CaCl_2$ which may because of liming. These were the only two pedons with evidence of contamination. Soils that may have been limed had higher pH in the surface horizons than expected and it is possible that the horizons have higher base status than that encountered in unlimed soils. Sampling the bottom of pits with bucket augers, while not ideal, was necessary when there was no other way to obtain samples from between rock fragments. There is no evidence that the horizons sampled with bucket augers were contaminated. All of the organic soils (sampling class HST) were sampled with augers.

Field Duplicate Sampling and Quality Control Samples

Field duplicates were supposed to be sampled by placing alternate trowelfulls of soil into two different sample bags. The objective was to obtain two samples that were as similar as possible. Two of the crews incorrectly sampled field duplicates by sampling two bags consecutively. This was done early in the project and was corrected during the audits. The only problem in the field associated with QC sample handling was that one crew dropped one of the QC samples while sampling PA009003.

Table 2-6 Samples with Possible Contamination

Pedon Number	Comments
PA021003	Horizon 7 was sampled with a bucket auger.
PA055002	Site may have been limed.
PA055007	The site, a hayland, may have been limed in the last ten years. The field measured pH was higher than what the crew expected.
PA055009	Surface disturbed by logging and traffic. Some O horizon material was mixed with the A horizon.
PA081006	The field may have been limed in the past.
PA105002	The field has been limed heavily in the past.
VA165005	The site is in an area of chicken coops and may have had fertilizer and/or chicken manure application.
WV083003	Higher than expected pH in the surface horizon, the pasture may have been limed.
WV093005	Horizons 7 and 8 sampled with a bucket auger.
PA025004, PA079002 PA081002, PA081006	There may be some material from adjacent horizons included in samples because they were sampled with augers. This is expected to be minor and should not significantly impact data quality.

Bulk Density Sampling

The objective was to obtain bulk density samples for every horizon for which routine samples were collected. Samplers attempted to obtain clods first and, if that was not possible, then to try to use the volume-replacement method. The volume-fill method was used if the other methods were not feasible be used. The completeness was 98 percent for bulk density sampling which is considerably better than previous DDRP surveys and is adequate for the project for one pedon. In the two previous DDRP surveys, the completeness for bulk density using clods alone was 48 percent and 61 percent, respectively.

Clod Sampling--

Deciding at which point a clod was too small to be useful was one of the biggest problems that developed with clod sampling. The protocols directed samplers to obtain clods 200 to 400 cm^3 in size, but did not specify any minimum size. A concern about sample size is that if a sample is very small, any errors in the determination of the weight and/or the volume would have a large effect on the final result. The other concern is that a very small sample may not be representative of the pedon because it may not contain the proper structural units or void spaces. The literature about clods does not discuss the minimum acceptable sample size. Terry et al. (1981) discuss that the selection of core size depends on the size of the largest material that needs to be included in the sample to make it representative (i.e. wood or rock fragments) and the thickness of the horizon. Homogeneous, subsurface horizons generally were said to yield good results with 3.5 cm cores (about 50 cm^3). Clods sampled in this project that were less than 50 cm^3 had more variability than larger ones (relative standard deviations [RSDs] > 25).

Alternative Bulk density Methods

Volume-Replacement Sampling--

The soil scientists sampled both clods and volume-replacement for some horizons at the beginning of sampling as requested. During the course of sampling, very few horizons were sampled using the volume-replacement. One reason for the few samples using this method was that the crews made an extra effort to sample clods. There were many horizons that could not be sampled using clods that were not suitable for volume-replacement sampling. Thin near surface horizons with irregular horizon boundaries were difficult to sample using volume-replacement because a level step could not be made. Horizons with a large amount of rock fragments were also difficult to sample using volume-replacement because of the problems making a level step.

Volume-Fill Sampling--

The volume-fill method worked well for the horizons, described above, where neither clods nor volume-replacement samples could be obtained. The volume-fill method worked most easily in horizons with loose, friable material without a large number of rock fragments. It was more difficult to pack the cylinders of known volume without getting unwanted void space when there were many rock fragments.

Sample Labeling

The Sampling Training Workshop paid particular attention to the proper completion of labels because of past labeling problems in the DDRP. A review of the preparation laboratory sample receipt log indicated that there were no apparent problems with labeling. Therefore, it appears that focused training had a positive effect.

Crew Logbooks

Coffey et al. (1987a; 1987b) recommended that standardized format logbooks be used to promote uniformity in the information documented. The level of detail that soil scientists recorded in their logbooks varied from crew to crew. The structured format helped ensure that similar types of information were being recorded. The standard format made it easier to resolve questions that arose during data validation. The types of situations that were resolved included soil classification, the lower depth of sampling, site selection, and possible contamination. The structured logbook is presented in the protocols in Appendix A.

Sample Transport and Storage

The sample storage and transport procedures were designed to decrease sources of possible contamination and to prevent mishandling of samples. The procedures also sought to ensure that the organic matter in the soils would not undergo changes because of increased temperature. The cool temperatures were expected to minimize, but not stop, transformations. The protocols called for storage near 4°C and crews used several means to accomplish that. Samples were kept cool in refrigerators at SCS field offices, stores, or crew member houses, in foam coolers with frozen gel packs that were changed daily, and in the cab or bed of pickup trucks when sampling extended into December. Samples were to be kept cool, but were not supposed to freeze.

Samples were carried to pickup trucks or vans by hand, backpack, or in all-terrain-vehicles. No samples were destroyed or contaminated in transport. The samples were shipped by overnight carrier to the preparation laboratory in Las Vegas. The preparation laboratory sample receipt log indicated that all samples were received in good condition.

Exit Meeting

An exit meeting for the Mid-Appalachian soil sampling took place in March 1988 in Las Vegas, NV. The purpose of the meeting was to obtain information about any departures from protocols, special cases, and field operations. The participants responded to a questionnaire both orally and in writing, the results were collated, and the final result was verified by the participants.

The participants thought that the sampling training workshop was effective training but that the crews would have understood the protocols more quickly if they had been provided with a flowchart of the required field procedures. In the DDRP Northeast survey, the soil scientists in NY developed such a flowchart and it was very effective. The PA personnel suggested that it might have been effective to have had a training session on their own following the sampling training workshop.

Some of the participants felt that the first field visit by the QA Coordinator should have been a training visit rather than an audit. The first audits were awkward at times because the auditors wanted to assess if the crew already understood the protocols while at the same time, the crews were asking the auditors to explain the protocols. It was suggested that the auditors needed to clearly explain that they were there primarily as observers and to answer questions. One crew was upset that the auditors did not help more with sampling, because the auditors did not explain that they were only permitted to observe, not to participate in the sampling.

The crews reported that they were kept well stocked with supplies with a few exceptions. Crew PA03 did not receive a stopper for their graduated cylinder, but they never needed it because they did not use the volume-replacement method. The crews said that they received far too many stake wire flags but too few golf tees to mark horizon boundaries.

Site selection was discussed and the problems with vegetation class have been discussed previously. Gaining permission from landowners was not a major problem. The crews did not have any major complaints about the profile description forms even though it took longer to write the descriptions because of the newness of the form and the codes. One crew was confused about the codes for the size of rock fragments because there was a code for pebbles and not gravel. Gravel is a collection of pebbles which are rounded, subrounded, angular, or subangular rock fragments 2 to 7.6 cm in diameter (Soil Survey Staff, 1983). The crews were asked to describe pores for which some describers were not adequately experienced. The EMSL-LV QA staff reported that the most frequent problems with the descriptions were hydraulic conductivity, percent clay, and moist color locations not being recorded. There were no major problems reported with photographic documentation. The photogray cards should have had an entry for the date. The crews would have liked to have received instruction manuals for the cameras but the manuals could not be located.

The most common complaint about clod sampling was the difficulty in determining the minimum acceptable size. The problems with the volume-replacement method were that it was hard to tell if the excavations were being filled with beads, and one crew had problems with beads clumping together because of static electricity. The crews said that they thought that unwanted void spaces were included in volume-fill samples when there was a high rock fragment content.

Conclusions About Soil Sampling

The soil sampling effort obtained the required samples and stayed close to the schedule. One hundred percent of the preselected pedons were sampled. The site selection procedures went smoothly and the protocols were followed with minor deviation. There were minor cases where the direction of transects for site selection were not chosen according to protocols. There were a few minor departures from vegetation class selection, but they did not adversely affect the usefulness or quality of the data. There were no major difficulties with pedon excavation. Organic soils must be sampled with an auger and/or shovel not by digging pits. Wet soils are difficult to excavate because they fill up with water and the sides of the pit may be unstable. Soils that contain a large amount of rock fragments, such as some of the soils formed in alluvium, were difficult to excavate. Clods less than 50 cm^3 showed the most variability but useful clods were obtained that were 25 cm^3. The site and soil profile for each pedon was described in detail and photographed. Sufficient samples were obtained to characterize the pedons. All of the samples were received in good condition at the preparation laboratory.

3 QUALITY ASSURANCE (QA) PROGRAM

QA PROGRAM DESIGN

The QA program was developed to ensure that the data collected would be of acceptable, known quality and that there would be sufficient supporting documentation to assess data quality. The first step in the assurance of quality was to verify that the work was being carried out by experienced and qualified personnel. This was achieved by cooperating with the SCS which has a staff of highly qualified soil scientists. The soil sampling protocols are based on NCSS procedures so the SCS soil scientists were already very familiar with the general approach of the soil sampling. The Sampling Training Workshop was designed to familiarize the soil scientists with the special requirements of this project and explain any differences in the way that the NCSS normally samples soils. Sampling crews were visited in the field for systems audits by the RCC, a representative from the SCS State Soils Staffs, and by representatives of the USEPA. The evaluation of quality for this project was primarily through the expert judgement of the auditors and by evaluation of written documentation. There were also more quantitative evaluations of based on duplicate samples and QC samples.

MEASUREMENT QUALITY OBJECTIVES

Quality goals for the duplicate and QC samples were established at a level that the project staff hypothesized were necessary and reasonable. These quality goals were expressed as measurement quality objectives (MQOs) which are specific numerical goals that apply to comparisons of specific samples. The precision MQOs of the field duplicates were twice that of duplicates prepared at the analytical laboratories. Thus, the goal was that the sampling bias would have a maximum of twice the bias of the laboratory analyses. The precision MQOs for analyses of field duplicates analyzed at the preparation and analytical laboratories are presented in Tables 4-2 and 4-3 in Appendix B. The accuracy goals for QC samples were established with data previously obtained using a biweight approach (Papp et al., 1989).

LABORATORY ANALYSES

Preparation Laboratory

The results from the preparation laboratory for pH and percent organic matter content of field duplicates and field audit samples were evaluated to assess sample precision and to detect sampling bias while sampling activities were proceeding. The conclusion of the DDRP QA staff was that there was no detectable sampling bias as revealed by the QC samples. The MQOs discussed earlier were applied to the precision of the routine samples against their field duplicates. Control limits for the performance evaluation samples were developed using previous data (Papp et al., 1989). The results listed in Table 3-1 were evaluated but supporting evidence (accompanying QA samples) showed that there had been no detectable contamination or sampling bias.

Analytical Laboratories

Evaluation of data from the analytical laboratories was the responsibility of EMSL-LV and the results are discussed by Byers et al. (1990). The field duplicates were evaluated using the MQOs listed in Appendix B. The field duplicate for pedon PA105002 did not meet MQOs for Ca exchangeable by NH_4OAc and $CaCl_2$. This pedon was identified with potential contamination from liming (Table 2-5). Byers et al. (1990) reported the precision of field duplicates tended to be lower than for preparation and analytical duplicates. This is expected because preparation and analytical duplicates are made after the soil has been thoroughly homogenized. All of the field duplicates and field audit samples were not sent to the analytical laboratories because of a constraint on the number of samples that could be analyzed. The samples that were not sent to the analytical laboratories were analyzed at the preparation laboratory and showed no indication of bias.

AUDITS

There were three different auditors who conducted systems audits of the crews. The auditors accompanied field crews to sample pedons to observe whether or not crews were following the protocols for site selection, photographic documentation, site and soil profile description, soil sampling, duplicate and performance evaluation sample handling, transportation and storage of the samples.

The RCC and SCS State Soils Staffs prepared independent site and profile descriptions. The USEPA auditors focused their evaluation on adherence to protocols and did not prepare independent descriptions. The frequency and timing of the audits are summarized in Table 3-2.

Table 3-1 Flagged Samples From Preparation Laboratory Analyses

Pedon ID	Sample Type[a]	Parameter[b]	Comments
WV075003	QC	PH_MP	0.28 pH units above upper control limit of 5.79
PA107001	QC	PH_MP	0.10 pH units above upper control limit of 5.26. The precision of the pair is 0.003 vs MQO of 0.1.
PA033005	QC	PH_MP	The pair is 0.30 and 0.16 pH units below lower control limit. The precision of the pair is 0.09 vs MQO of 0.1.
PA107006	FD	PH_MP	Precision is 0.28 and the MQO was 0.20.
PA113001	QC	OM_LOI	One sample was 0.11 percent organic matter above the upper control limit of 0.48
PA107006	QC	OM_LOI	One of the pairs was 2.33 above the upper control limit of 6.01, while the other pair was very close to the mean expected value.
PA081001	FD	OM_LOI	The precision was 25 percent RSD versus the MQO of 20 percent.

---

[a] QC = quality control samples; FD = field duplicate samples sample
[b] PH_MP = pH of field moist sample; OM_LOI = organic matter determined by loss on ignition

Table 3-2 Audits of Field Crew

Crew	Auditor(s)	Date	Pedon ID	Watershed Name	Watershed ID
PA01	RCC and SSS	09/21/88	PA105001	Upper Dry Hollow	2C029002
PA01	SSS	11/16/88	PA099003	Boyers Run	2B036028
PA01	USEPA	09/22/88	PA105002	Upper Dry Hollow	2C029002
PA01	USEPA	11/07/88	PA107013	Lower Swatara Creek	2B036046
PA02	RCC and SSS	09/28/88	PA005001	Burns Creek	2B036062
PA02	USEPA	09/23/88	PA009005	Piney Creek	2B041008
PA02	USEPA	11/09/88	PA055001	Fulton Run	2C041002
PA03	SSS	12/16/88	PA027003	Wolf Run	2C029020
PA03	USEPA	11/08/88	PA033005	Coldstream Run	2C028070
WV01	RCC and SSS	10/05/88	WV075006	Clubhouse Run	2C047010
WV01	SSS	10/19/88	WV093006	Coal Run	2C041051
WV01	USEPA	09/27/88	WV075002	Hateful Run	2C046034
WV01	USEPA	11/03/88	VA165003	Bible Run	2B047036
WV02	RCC	10/08/88	WV093002	Right Fork Clover Run	2C041045
WV02	USEPA	09/27/88	WV101003	Johnson Run	2C046033

RCC Field Visits

The RCC conducted a field visit for each of the four original crews. The RCC completed an audit questionnaire form (Appendix B), prepared an independent soil profile description, and discussed the audit with the crew. The audits of the RCC are described in more detail in Appendix C.

The RCC's overall impression of the crews was quite positive. The RCC reported that Crew PA02 was correctly sampling field duplicates, but in his report he described the wrong method. The protocols specify that field duplicates should be sampled by placing alternate trowelfulls of soil into two different bags. The procedure described by the RCC was that the horizon was sampled, sieved, mixed, and then bagged as two samples. Field duplicates sampled in such a manner have a greater chance of being different and of being contaminated during sampling.

State Soils Staffs Field Visits

Crew PA01 was audited twice by the SSS because there was a change of crew leaders. The first audit was done in conjunction with the RCC. Site selection was done following the protocols and the SSS observed the site selection of the next two sampling sites. Samples were obtained according to protocols and were labeled correctly. The first audit report of Crew PA01 stated that they were doing an excellent job of sampling. The site selection for the second audit was done prior to the visit by the SSS, but they discussed the procedures. The SSS reported that the crew had been following site selection protocols. Clods, though difficult to obtain, were sampled and the crew did not use any of the alternative bulk density methods. There were no problems identified by the independent profile descriptions of both sites. Samples were transported and stored correctly.

The audit of PA02 was also done in conjunction with the RCC. Site selection procedures were followed and a suitable pedon was located. Bulk samples were obtained correctly. The crew did not correctly sample the field duplicates and they were instructed in the proper procedure. They had taken two separate samples consecutively rather than placing alternate trowelfulls in two separate bags. Random number tables were not used to determine transect direction, but rather 3 people picked numbers and the sum was divided by 3. Clod samples were difficult to obtain, but they were able to collect clods for every horizon. There was no significant difference between the routine and independent descriptions. The overall impression was that the crew was doing a good job and was following the protocols.

The SSS spent two days with Crew PA03 observing site selection and sampling. The principal crew members of this crew had been members of the other crews and were very familiar with the protocols. One of the soil scientists who was working with the crew during the days of the audit participated in the DDRP sampling and mapping in the Northeast soil survey. The crew correctly located and excavated the site. The description was well done, but there was some doubt about the field measured pH because of the low temperatures which was noted on the 232-form. Field duplicates and performance evaluation samples were not handled because the crew had run out of these samples. The preparation laboratory was not contacted for more samples. This was not a problem because there was a sufficient number of these samples. The clod samples took longer to dry than anticipated because of the low temperatures, but they were dry when packaged. The crew did not use the volume-replacement or volume-fill methods.

The audit of WV01 took place in one of the most inaccessible watersheds in this survey that required a walk of 1.5 hours. The crew had excavated a pedon the day before the audit, but the SSS decided that it was unsuitable because it was too deep. The sampling class was supposed to be TWM and the pit was greater than one meter to bedrock. The crew then correctly located a suitable sampling site. The vegetation class was correct. Clods for the C horizon were very small so the crew also collected volume-fill samples. The SSS concluded that the independent description was sufficiently similar to the description by the crew. The differences were depths and thicknesses of horizons. The SSS felt that the crew was operating acceptably, particularly considering the inaccessibility of many of their sites.

The SSS audit of WV02 was conducted in conjunction with the RCC. The site was located the day before the audit and it was found exactly at point one so transecting was not necessary. The vegetation class was suitable for sampling. The SSS concluded that the differences between the routine and independent descriptions were minor. The SSS described Bt1 and Bt2 horizons with a combined thickness of 32 cm and the crew described one Bt of 29 cm. The clod samples collected from the A horizon were fairly small.

US Environmental Protection Agency Quality Assurance Audits

The DDRP QA Coordinator from ERL-C audited all of the crews that were operating at during the first few weeks of sampling in late-September. Crews PA01 and PA02 were visited while they were sampling their fifth pedon, WV01 during their first pedon, and WV02 during their eighth. The PA03 crew had not begun work and most of the personnel that would be on that crew when it formed were formerly members of PA01. It was not ideal time to audit WV01 because they had not yet had time to develop their sampling techniques, but the audits of the other crews could not wait.

A departure from protocols was that 3 out of 4 crews collected field duplicates improperly. These crews were either sampling one bag then another or sampled a large amount that they mixed and subsampled rather than placing alternates scoops of soil into two different bags. Crews were shown the correct method and the rationale for the procedure was discussed. The rationale is that the field duplicates are meant to measure how well crews can obtain two independent samples rather than how well they can homogenize samples. If the measured properties of a routine sample and its corresponding field duplicate are significantly different, it might indicate sampling bias (perhaps not collecting representative samples) or contamination during handling and shipping.

One crew was found to have sampled a pedon that did not have the preselected vegetation class and they were asked to follow the protocols in the future. Crews were told to try to verify that a pedon is suitable for sampling before making a full sized excavation. One crew made a large excavation only to find that there was a fragipan at 75 cm that disqualified the pedon from the preselected sampling class.

The importance of trying to excavate as close to two meters depth as possible was discussed. In very difficult circumstances, such as rocky alluvium, crews were instructed to excavate to 1.5 m if they were reasonably sure that the material was uniform to two meters. The protocols state that unless bedrock is encountered, that the excavations should be to two meters deep. This is excessively difficult in some situations but the point of the requirements of the protocols was to stress that the project is interested in material that may be below the zone of apparent soil development.

There was a discrepancy among crews in the placements of the location crews defined as zero depth. The zero point for profile descriptions, as defined by NCSS protocols (Soil Survey Staff, 1983), is the top of the mineral surface or the top of an Oa horizon. Some of the crews defined zero as the top of the mineral surface regardless of whether or not there was an Oa horizon. It is important that crews use the same definition to insure uniformity in depth-to-bedrock, soil thickness, and other variables.

Some of the soil scientists making the profile descriptions did not have experience describing pores. The SCS has standard terminology that has been established for some time, but in soil survey work this parameter is not routinely evaluated. The DDRP requested this information because it might aid in hydrological interpretations of some sites. The descriptors for shape and continuity were discussed with crew personnel.

The crews were dipping some clods in saran solution for longer than two seconds. That this could introduce some error was pointed out to the personnel. If clods are immersed in the solution for too long, the solution can seep into the clod rather than simply coating the clod. Bubbles can often be seen when clods are immersed too long which suggests that pore space is filling up with solution thus displacing air. The minimum size clod allowed was discussed on every audit. Crews were told that it was better to sample small clods than use the alternative bulk density methods.

Crews were storing samples for as long as a week in coolers with the gel packs changed daily. Crews were encouraged to find refrigerator space, but if this was not possible the use of coolers for storage was approved. In that case they were told to make more regular shipments to avoid a backlog of samples needing refrigeration.

The second round of audits were conducted in mid-November. A new sampling crew PA03 was added to try to keep on schedule and the key personnel on that crew had been on the crews that were audited first. Crew WV02 had just finished sampling by doing overtime work.

No serious departures from protocols were encountered during the second round of audits and discrepancies discovered in the first audits had been corrected. One important concern encountered was that one of the crews had not been using a procedure that gave them 1 of 8 random compass points to transect for sampling sites. The crews had been instructed to use the random number tables provided. One crew used two dice to obtain 1 of 8 random points. Another crew used one dice toss to obtain 1 of 4 compass directions. This meant that the intermediate compass points (northeast, southeast, etc) had a zero probability of being selected.

In one case, the crew felt that the vegetation had been incorrectly mapped. The problem was that they thought that none of the choices of vegetation was appropriate. The vegetation class preselected for sampling was hardwoods, but the site was sphagnum moss organic soil. The soil scientists on the crew were familiar with the mapping that had been submitted to ERL-C and they knew that areas were mapped as conifer (hemlock). Apparently the map was misread at ERL-C when the preselection process took place.

During the second round of audits it was realized that the sampling crews had not been given explicit instructions about what (if anything) to record as the lowest depth. The lower depth on the lowest horizon is obvious when bedrock is encountered in the excavation. In cases where a pedon is deep or where it is not possible to excavate deeply, the lowest extent of the lowest horizon described is not known so the correct lower depth is the bottom of the pit "+". The soil scientists often wrote a dash rather than putting a depth measurement because they did not know the exact lower depth. The crews were told to write down the depth to the bottom of the pit and make a note that it is not the bottom of the horizon. The descriptions that were already submitted were completed with lower depths from the notes on the descriptions or in the logbooks.

One crew stopped using cheesecloth to line holes for the volume-replacement bulk density method and did not try to retrieve the beads. They felt that there were introducing error because they couldn't get the cheesecloth to lie flat. None of the other crews made this complaint. The crew was asked to use cheesecloth in the future to ensure comparability among the crews. They were advised to make sure that the cheesecloth was not too thick or starched so that they could avoid the problem of getting it to lie flat.

INDEPENDENT SOIL PROFILE DESCRIPTIONS

Independent profile descriptions were made by the SCS State Soils Staffs and the RCC of the same pit face. In some cases a single pedon was described by both of them. A summary of the pedons with independent descriptions and describers is given in Table 3-3. The critical parameters to the DDRP from the descriptions are the sampling class, horizon designation, horizon depth, horizon thickness, soil depth, and rock fragment content. Soils data are grouped by the DDRP using sampling class and master horizon designation. The amount of fine-soil material in horizons is calculated using horizon thickness and rock fragment content. Soil depth is important to determine the lowest depth and total volume of soil that will react with acidic deposition. Field measured pH is not used in the DDRP analyses, but provided the field crews with indications that fields may have been limed.

Table 3-3 Identification Numbers and Authors of the Independent Descriptions

Pedon ID	Watershed ID	Crew	State Soils Staff	RCC
PA105001	2C02902	PA01	X	X
PA099003	2B03602	PA01	X	
PA055001	2B03606	PA02	X	X
PA027003	2C02902	PA03	X	
WV093006	2C04105	WV01	X	
WV075006	2C04701	WV01		X
WV093002	2C04104	WV02	X	X

PA105001

This pedon was described by Crew PA01, the PA SSS, and the RCC. The site descriptions are nearly identical except that the SSS called the physiography "dissected-plateau" and the others called it "high hills." There is really no difference between the terms because high hills can be a manifestation of plateau dissection. All of the descriptions indicated that the parent material origin is residuum. The RCC described the parent material as sandstone while the others called it shale-siltstone. The crew described the parent material as shale-siltstone, but described the rock fragments as being sandstone.

The profile descriptions are very similar except for one important detail. The SSS described different horizons for the lower portion of the pedon than both the crew and the RCC. The crew sampled from 63 cm to 122 cm as C horizons, but the SSS labeled it as a Bt horizon. This difference would affect how the data are used because the DDRP aggregates data by major horizon. The SSS described the argillic horizon to a much lower depth than the other describers. The crew described coats in the C horizons, but did not call them clay films.

The clay estimates by the crew matched fairly well with the RCC and the SSS. Clay estimates did not vary by more than 10 percent and the textural classes were always the same. Rock fragment estimates were very close and also never varied more than 10 percent for crew vs RCC and 15 percent for crew vs SSS. The RCC described fewer rock fragments in the particle size control section than the crew.

The crew and the RCC obtained nearly exactly the same pH (both used chlorophenol red). The pHs were commonly within 0.20 pH units with a maximum difference of 0.30. The SSS did not determine the pH.

In summary, the results of the independent description suggest that the crew did a good job of describing the pedon. There is a fundamental difference in horizonation between the SSS and the other descriptions that affects sampling. It appears that the crew was justified in describing the horizons they way they did. The RCC and the SSS agreed that the description by the crew was acceptable.

PA099003

Crew PA01 was audited a second time by the SSS because there was a new crew leader. The site descriptions were very similar except that the crew said that the geomorphic position was "shoulder head slope" and the SSS called it "back slope side slope". This has no effect for the DDRP analyses, but the crew does imply that the site is in a higher geomorphic position than the SSS. The landuse described by the crew was forest land, not grazed, and the SSS called it "abandoned cropland" which shows that more explicit definitions of landuse in the protocols might have been useful.

The profile description by the SSS compared very closely with the crew except for some horizon nomenclature. The C1 horizon described by the crew was labeled BC by the SSS. This would cause the data from this sample to be aggregated with B rather than C horizons. A BC horizon, by definition, has properties that are transitional between two designations and would not likely skew the C or B aggregated values excessively. The horizon depths were very similar between the two descriptions which suggests that the horizon boundaries were evident in the field and the crew drew them appropriately. The crew described a horizon BC that the SSS labeled as Bt3 which would not affect aggregation and would not have changed the depths of the particle size control section. The crew called the horizon above hard bedrock a C3 horizon and the SSS called it a Cr which would not affect aggregation because they are all C horizons.

The estimates of rock fragment content differed somewhat between the descriptions. The estimates by the SSS were consistently lower by as much as 15 percent. The crew classified this soil as loamy-skeletal while the SSS classified it as fine-loamy. This has no effect on the DDRP sampling class designation, but it does affect the rock fragment correction during aggregation. The textural classes for both descriptions were the same (except for a rock fragment modifier). The estimates of percent clay were often within 2 percent and differed by no more than 6 percent. The measured pH differed by 0.8 pH unit for one horizon and differed by less than 0.4 for all the other horizons. A pH difference of 0.8 acceptable, but more than 1 would be unacceptable. In conclusion, the descriptions were in very close agreement except for estimates of rock fragments and a minor details about horizon designation. The SSS was satisfied that the description by the crew was acceptable.

PA055001

This pedon was described by crew PA02, the RCC, and the SSS. The crew said that the runoff was moderate and both the SSS and the RCC called it rapid. This has no effect on the way that the DDRP uses the data.

The sample class and family classifications were the same for all three descriptions. The major difference is that the crew described the 26 cm above bedrock as a C horizon and the RCC subdivided the same layers as Bw2 and BC horizons which creates differences in aggregation. The SSS also called this layer C, but had slightly different depths. The SSS described no A or E horizons as in the other two descriptions. There was a 20 percent rock fragment content difference between the crew and the RCC descriptions, but they agree more closely with the SSS. All descriptions determined that the pedon has a loamy-skeletal particle size classification. The field measured pH values were within 0.1 pH units for the crew and RCC descriptions, but the SSS did not measure pH. The horizon depths were within 3 cm of each other for the crew and the RCC. In conclusion, the two descriptions were very similar and differed significantly only in a horizon designation for one layer.

PA027003

This pedon was described by crew PA03 and the SSS. The site descriptions are nearly identical except for the physiography and runoff. The crew description states that the physiography is a structural bench in a deeply-dissected plateau, but the SSS described it as a slough in hills. The two physiographies do not exactly contradict each other, but rather describe things from a slightly different perspective. Slough is a general term for waterlogged ground; the site was wet and thus it is an appropriate term. Structural bench is appropriate if the fairly level site was caused by the shape of the bedrock. It has already been discussed above that "deeply-dissected plateau" could be manifested as hills or mountains.

The profile descriptions by the crew and the SSS were very similar. The horizon designations for both the crew and SSS descriptions were identical and the horizon depths were all within five centimeters. The field measured pH did not vary by more than 0.2 pH units and the percent clay estimates were either exactly the same or within 3 percent. The rock fragment estimates were exactly the same in two-thirds of the horizons and in the remainder only varied by 2 percent. The description of mottles was also very similar among the describers which is an indication of the aquic moisture regime. In conclusion, there were no significant differences between the descriptions.

WV093006

The physiography was described by the crew as "hillside in deeply dissected plateau" while the SSS called it a "mountainside in mountains." There is no problem with this discrepancy of dissected-plateau versus mountains. The crew described the runoff as very rapid and the SSS called it rapid which appears to be the most appropriate entry. The DDRP does not use runoff in analysis, so this discrepancy is not serious.

The crew and SSS profile descriptions were very similar. The horizons were the same and the horizon depths varied two centimeters at most. The textural classes were identical for both descriptions and the estimated percent clay was the same or within four percent. The rock fragment estimates were nearly identical except in the lower part of the control-section where the crew estimated 40 percent and the SSS 55 percent. This higher value would not change the particle size classification to sketelal (which would not affect the DDRP sampling class, regardless). The pH measurements differed by no more than 0.2 pH units in both descriptions. In conclusion, the two descriptions did not differ in any significant way.

WV075006

The site descriptions for the crew and the RCC closely agreed. The crew thought that the pedon was well drained, while the RCC said it was moderately well drained. The mottling (common, distinct) began near 91 cm depth. The drainage class uncertainty has no effect on the data uses for the DDRP because both well and moderately well drained soils are in sampling class FLW.

There are some substantial differences between the profile descriptions. The sampling crew chose to call the uppermost four centimeters of mineral soil C because it was a layer of sandy material that had been deposited so recently there was no significant soil development. The RCC called the top seven centimeters an A horizon which is more appropriate because A horizons are surface horizons and may be associated with disturbances. This was not corrected during the audit, but was corrected before data aggregation by the ERL-C DDRP QA coordinator. If the RCC description was used rather than the crew's, the soil from 48 cm to 91 cm would have been sampled as B rather than C. The RCC labeled it BC because it is a transitional horizon. Transitional horizons could resemble either adjacent horizon, so it is not a problem that the descriptions differ.

The RCC consistently estimated lower clay content than the crew, but the maximum difference was seven percent which is very close. The rock fragment estimates were very similar if compared on a total basis, but there were some differences in the size classes of the rock fragments. The pH values varied more than other descriptions. The maximum difference was 0.5 pH unit. This was because the crew used bromcresol-green reagent for the upper 93 cm of the pedon while the RCC used chlorophenol red.

The descriptions appear at first look to be quite different, but for sampling and data aggregation purposes for the DDRP, they are very similar. The only noticeable result is that roughly 50 cm of soil material was sampled as BC rather than C as the RCC described. The depths of the horizons varied somewhat in a few cases, but not significantly.

WV093002

This pedon was described by the crew, the RCC and the SSS. The site descriptions were nearly identical except that the RCC stated that the geomorphic position was a "shoulder nose slope" while the other two describers called it "back slope side slope". This difference is not significant.

The horizons and depths were very close for all descriptions, with the major difference being that the crew did not subdivide the Bt horizon into Bt1 and Bt2 horizons. All of the descriptions had the same textural classes and clay estimates within 5 percent of each other. The exception was that the RCC estimated 10 percent clay, while the others estimated 20 and 23 percent. The field measured pHs were all within 0.1 unit. The rock fragment estimates were very close, except that the SSS was 10 percent below the others and the crew was 10 percent low for the C horizon. In conclusion, the descriptions were very similar and there were no significant differences.

Independent Description Conclusions

The conclusion made by the RCC and SSS who wrote the independent descriptions was that the descriptions made by the crews had no major problems. There were cases where the independent descriptions would have resulted in samples being taken from different depths than the sampling crew, but these were judged not to be significant. In most cases the site description, horizon designations, horizon depths, and rock fragment estimates were very close for the routine and independent descriptions. All of the describers agreed on assignment of sampling classes.

4 CONCLUSIONS AND RECOMMENDATIONS

TRAINING

The sampling training workshop by the USEPA was effective in introducing the methods to the crews. The crews would have learned the methods more quickly if there had been follow-up training sessions for the personnel from each state. The entire sampling process could be reviewed at such training sessions by several crews at once. This would promote consistency among the crews. Detailed flowcharts are excellent learning tools for complicated protocols, such as these. A useful flowchart would detail each task in order and list all necessary equipment.

SITE SELECTION

The only discrepancies that occurred during site selection were with vegetation classes. It is very important to be sure that the correct vegetation classes are read from maps, but some sampling sites were near vegetation map unit boundaries which created some uncertainty. It would have been better to have allowed crews to sample a vegetation class at one point, if the next point has the same vegetation class found. There was at least one instance where a crew was not permitted to sample a forested site at point 1, but had to sample a forested site at point 2.

SITE AND SOIL PROFILE DESCRIPTIONS

The form used for the descriptions was very useful. One recommendation is that space for horizon notes should have been more structured entry space, so that notes pertinent to a given horizon could stay with that horizon. More discussion in training should be given to use of landform terms. This would result in more uniformity for physiography and geomorphic position description.

The field measured pH is not a value used by the DDRP after sampling. Field moist pH was determined at the preparation laboratory to identify soils with carbonates. The analytical labs measured pH in three different solutions. The field measured pH was useful because it gave crews feedback as to whether the soil was typical. There were several cases where crews reported that the surface pH was higher than expected. Landuse suggested that the field may have been limed. The crews might not have written down that observation had they not determined the pH. Field measured pH is recommended for all soil sampling projects. In some projects the field pH might be needed to determine sampling class assignment.

PHOTOGRAPHIC DOCUMENTATION

The photographic documentation was successful and produced high quality slides of most of the pedons. Proper documentation of the site and soil profile are easy and are not overly time consuming. It is recommended that film of at least ASA 200 speed be used because of lighting problems in forested sites.

BULK SAMPLING

Sampling organic and wet soils has posed a special problem in all of the DDRP surveys. The techniques used for sampling wet soils were successful in this project, but might have been more successful if the pumps had longer hoses.

BULK DENSITY

The increased emphasis on getting bulk density samples resulted in greater completeness for clods. On the basis of the bias estimates for different size clods, it appears that clods larger than 50 g/cm^3 are most useful.

The volume-replacement method worked well, but had limited usefulness. It was not very successful for use in horizons where clods could not be obtained such as thin surface horizons or rocky lower horizons. The volume-fill method worked very well and is recommended as a good method to use when clods or cores cannot be obtained.

CREW LOGBOOKS

Standardized crew logbooks were successful and they are recommended if they are designed to get necessary information and not burden the crews with extra paperwork. The logbook used here was successful except that a section that asked the crew to list all samples proved to be extra work for the crew that was not justified. The crews were told that they were not required to complete that section because the samples were listed in the sample shipment section.

AUDITS

The field audits have been shown to be very useful because they verify that crews understand the protocols. In these activities some crews were audited as many as four times. It is recommended that crews be audited once at the beginning of the project and again halfway through the project by QA representatives. The one audit per crew by the SSS proved very useful. The audits by the RCC were useful to promote consistency among crews from different states.

INDEPENDENT SITE AND SOIL PROFILE DESCRIPTIONS

The independent profile descriptions were useful for checking the description variables most important to the DDRP which are sampling class, horizon designations, horizon depths, and rock fragment content estimates. The independent descriptions promote uniform concepts about soil description by providing a forum for discussion about diagnostic horizon identification, horizon designation, horizon depths, and rock fragment estimates.

STORAGE AND TRANSPORTATION

The samples were stored in a cool place if not shipped to the preparation laboratory within 24 hours Samples were stored in refrigerators or in coolers with frozen gel packs. No samples were lost, destroyed, or contaminated in transit to the preparation laboratory.

OVERALL CONCLUSIONS

The sampling project was very successful because it resulted in the collection of high quality samples from 100 percent of the pedons chosen for sampling. The crews carefully handled all of the required performance evaluation samples, with a few exceptions, and the analysis of these samples indicated that there was no significant sampling bias or contamination. The necessary photographic and written documentation was obtained. Samples were stored and transported to the preparation laboratory according to the protocols.

5 REFERENCES

Blume, L.J., D.S. Coffey, and K. Thornton. 1987a. Field Sampling Manual for the National Acid Deposition Soil Survey. Appendix A IN Coffey, D.S., M.L. Papp, J.K. Bartz, R.D. Van Remortel, J.J. Lee, D.A. Lammers, and G.R. Holdren. 1987a. Direct/Delayed Response Project: Field Operations and Quality Assurance Report for Soil Sampling and Preparation in the Northeastern United States, Volume I Sampling. EPA/600/4-87/030. US Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Las Vegas, NV.

Blume, L.J., M.L. Papp, K.A. Cappo, J.K. Bartz, D.S. Coffey, and K. Thornton. 1987b. Sampling Protocols for the Southern Blue Ridge Province Soil Survey. Appendix A IN Coffey, D.S., J.J. Lee, J.K. Bartz, R.D. Van Remortel, M.L. Papp, and G.R. Holdren. 1987b. Direct/Delayed Response Project: Field Operations and Quality Assurance Report for Soil Sampling and Preparation in the Southern Blue Ridge Province of the United States, Volume I Sampling. EPA/600/4-87/041 US Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Las Vegas, NV.

Byers, G.E., R.D. Van Remortel, M.J. Miah, J.E. Teberg, M.L. Papp, B.A. Schumacher, B.L. Conkling, D.L. Cassell, and P.W. Shaffer. 1990. Direct/Delayed Response Project: Quality Assurance Report for Physical and Chemical Analyses of Soils From the Mid-Appalachian Region of the United States. EPA/600/4-90/001. US Environmental Protection Agency, Las Vegas, Nevada.

Chen, C.W., S.A. Gherini, R.J.M. Hudson, and J.O. Dean. 1983. The Integrated Lake-Watershed Acidification Study. Volume I: Model Principles and Application Procedures. Final Report EA-3221, Electric Power Research Institute, Palo Alto, California.

Church, M.R., K.W. Thornton, P.W., Shaffer, D.L. Stevens, B.P. Rochelle, G.R. Holdren, M.G. Johnson, J.J. Lee, R.S. Turner, D.L. Cassell, D.A. Lammers, W.G. Campbell, C.I. Liff, C.C. Brandt, L.H. Liegel, G.D. Bishopp, D.C. Mortenson, and S.M. Pierson. 1989. Future effects of long-term sulfur deposition on surface water chemistry in the Northeast and Southern Blue Ridge Province: Results of the Direct/Delayed Response Project. EPA/600/3-89/061. US Environmental Protection Agency, Office of Research and Development, Washington, DC and Environmental Research Laboratory, Corvallis, Oregon.

Coffey, D.S., M.L. Papp, J.K. Bartz, R.D. Van Remortel, J.J. Lee, D.A. Lammers, and G.R. Holdren. 1987a. Direct/Delayed Response Project: Field Operations and Quality Assurance Report for Soil Sampling and Preparation in the Northeastern United States, Volume I Sampling. EPA/600/4-87/030. US Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Las Vegas, NV.

Coffey, D.S., J.J. Lee, J.K. Bartz, R.D. Van Remortel, M.L. Papp, and G.R. Holdren. 1987b. Direct/Delayed Response Project: Field Operations and Quality Assurance Report for Soil Sampling and Preparation in the Southern Blue Ridge Province of the United States, Volume I Sampling. EPA/600/4-87/041 US Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Las Vegas, NV.

Cosby, B.J., G.M. Hornberger, and J.N. Galloway. 1985a. Modeling the effects of acid deposition: Assessment of a lumped parameter model of soil water and streamwater chemistry, Water Resour. Res. 21:51-63.

Cosby, B.J., G.M. Hornberger, R.F. Wright, and J.N. Galloway. 1985b. Modeling the effects of acid deposition: Estimation of long-term water quality responses in a small forested catchment, Water Resour. Res. 21:1591-1601.

Cosby, B.J., G.M. Hornberger, S.H. Rastetter, J.N. Galloway, and R.F. Wright. 1986a. Estimating catchment water quality response to acidic deposition using mathematical models of soil ion exchange processes. Geoderma 38:77.

Cosby, B.J., R.F. Wright, G.M. Hornberger, and J.N. Galloway. 1986b. Modeling the effects of acid deposition: Control of long-term sulfate dynamics by soil sulfate adsorption. Water Resour. Res 22.

Gherini, S., L Mok, R.J. Hudson, G.F. Davis, C.W. Chen, and R.A. Goldstein. 1985. The ILWAS model: Formulation and application. Water, Air, and Soil Pollut., 26:425.

Kern, J.S., D.A. Lammers, D.L Cassell and W.G. Campbell. 1990. Direct/Delayed Response Project: Field Operations and Quality Assurance Report for Mapping Activities in the Mid-Appalachian Region of the United States. EPA/600/3-90/035. US Environmental Protection Agency, Environmental Research Laboratory, Corvallis, Oregon.

Lee, J., D. Lammers, M. Johnson, R. Church, D. Stevens, D. Coffey, R. Turner, L. Blume, L. Liegel, L. and R. Holdren. 1989. Watershed surveys to support an assessment of regional effects of acidic deposition on surface water quality. Environmental Management, Vol. 13, No. 1, pp 95-108.

Kern, J.S. and J.J. Lee. 1989. Evaluation of two alternative bulk density measurement methods. Abstracts in Agrononmy, American Society of Agronomy Annual Meetings.

Lee, J.J., D.L Stevens, J.S. Kern, and D.A. Lammers. 1990. Direct/Delayed Response Project: Mid-Appalachian Soil Correlation and Sampling Class Development Workshop. EPA/600/3-90/037. US Environmental Protection Agency, Environmental Research Laboratory, Corvallis, Oregon.

Lee, S. 1987. Uncertainty Analysis for Long-Term Acidification of Lakes in the Northeastern USA, Ph.D thesis, University of Iowa, Ames.

Nikolaidis, N.P. 1987. Modeling the Direct Versus Delayed Response of Surface Waters to Acid Deposition in Northeastern United States. Ph.D thesis, University of Iowa, Ames.

Papp, M.L., R.D. Van Remortel, C.J. Palmer, G.E. Byers, B.A. Schumacher, R.L Slagle, J.E. Teberg and M.J. Miah. 1989. Direct/Delayed Response Project: Quality Assurance Plan for Preparation and Analysis of Soils from the Mid-Appalachian Region of the United States. EPA/600/4-89/031. US Environmental Protection Agency, Las Vegas, Nevada

Papp, M.L and R.D. Van Remortel. in press. Direct/Delayed Response Project: Preparation Laboratory Operations and Quality Assurance Report for the Mid-Appalachian Soil Survey. US Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Las Vegas, Nevada.

Schnoor, L., N.P. Nikolaidis, and G.E. Glass. 1986. Lake resources at risk to acidic deposition in the Upper Midwest. J. Water Pollution Control Federation, 58:139-148.

Soil Survey Staff. 1975. Soil Taxonomy, Agriculture Handbook No. 436, US Government Printing Office, Washington, DC.

Soil Survey Staff, 1983. National Soils Handbook. US Government Printing Office, Washington, DC.

Soil Survey Staff, 1984. Soil Survey Laboratory Methods and Procedures for Collecting Soil Samples. U.S. Department of Agriculture, Soil Survey Investigations Report No. 1. US Government Printing Office, Washington, DC.

Soil Survey Staff. 1988. Keys to Soil Taxonomy (fourth printing). Soil Management Support Services technical monograph no. 6, Cornell University, Ithaca, N.Y.

Terry, T.A., D.K. Cassel, and A.G. Wollum, II. 1981. Effects of soil sample size and included root and wood on bulk density in forested soils. Soil Sci. Soc. Am. J. 45:135-138.

APPENDIX A:

DIRECT/DELAYED RESPONSE PROJECT:

SOIL SAMPLING MANUAL

FOR THE MID-APPALACHIAN REGION OF THE UNITED STATES

by

Jeffrey S. Kern
NSI Technology Services Corporation
USEPA Environmental Research Laboratory
200 SW 35th Street
Corvallis, Oregon 97333

Michael L. Papp
Lockheed Engineering and Sciences Company
1050 E Flamingo Road
Las Vegas, Nevada 89109

Jeffrey J. Lee
US Environmental Protection Agency
USEPA Environmental Research Laboratory
200 SW 35th Street
Corvallis, Oregon 97333

Louis J. Blume
US Environmental Protection Agency
USEPA Environmental Monitoring and Systems Laboratory
4220 S Maryland Parkway
Las Vegas, Nevada 89193

US Environmental Protection Agency
USEPA Environmental Research Laboratory
200 SW 35th Street
Corvallis, Oregon 97333

TABLE OF CONTENTS

FIGURES 60

TABLES 60

ACKNOWLEDGEMENTS 61

1 INTRODUCTION 62

2 FIELD PERSONNEL 63
  FIELD CREWS 63
  SAMPLING TASK LEADER 63
  QUALITY ASSURANCE (QA)/QUALITY CONTROL (QC) PERSONNEL 64
    USDA Soil Conservation Service (SCS), State Soils Staffs 64
    Regional Coordinator/Correlator (RCC) 65
    QA/QC Auditors 65

3 FIELD EQUIPMENT 66
  SITE SELECTION EQUIPMENT 66
  EXCAVATION EQUIPMENT 66
  SOIL DESCRIPTION EQUIPMENT 66
  PHOTOGRAPHIC EQUIPMENT 67
  SAMPLING EQUIPMENT 67
  CLOD SAMPLING EQUIPMENT 67
  VOLUME-REPLACEMENT SAMPLING EQUIPMENT 68
  VOLUME-FILLING SAMPLING EQUIPMENT 68
  TRANSPORTATION EQUIPMENT 68
  SHIPPING EQUIPMENT 68

4 SELECTION OF PEDONS TO BE SAMPLED 69
  DEFINITIONS 69
  IDENTIFYING A SUITABLE PEDON FOR SAMPLING 69
  EVALUATION OF FOREST COVER TYPE FOR POTENTIAL SAMPLING POINTS 71
  PROCEDURES FOR LOCATING A SUITABLE PEDON 71
    General Guidelines 71
    Procedure 72
  LOCATING SUITABLE PEDONS IN MAP UNIT INCLUSIONS 73

5 PEDON EXCAVATION 74
  STANDARD EXCAVATION 74
    Pit Size 74
    Steps in the Pit 74
  EXCAVATION OF SOILS WITH WATER TABLES 75
  EXCAVATION OF ORGANIC SOILS 75
  SOILS DIFFICULT TO EXCAVATE 75

6 SITE AND PROFILE DESCRIPTION 76
  INDEPENDENT PROFILE DESCRIPTIONS 77
  PROFILE DESCRIPTION 77
  PHOTOGRAPHS OF PROFILE AND SITE 78
  DOCUMENTATION 80

- 7 FIELD SAMPLING PROCEDURES 81
  - IMPORTANT POINTS CONCERNING SOIL SAMPLING 81
  - SAMPLING PEDONS 81
    - Field Sampling Protocols 81
  - SAMPLE SIZE 81
  - SAMPLING PROCEDURES 82
    - General Guidelines 82
    - Collecting Bulk Samples 83
      - Routine Samples– 83
      - Field Duplicates– 84
      - Field Audit Samples– 84
    - Sampling for Bulk-Density Determination 85
      - Clod Method– 85
        - Field Transport of Clods 86
      - Volume-Replacement Bulk Density Sampling-- 86
      - Volume-Filling Bulk Density Sampling-- 87
  - SAMPLE LABELING 87
    - DDRP Label A 88
      - Sample DDRP Label As-- 90
        - Routine Samples 90
        - Field Duplicate Samples 90
        - Field Audit Samples 91
        - Volume-Replacement and Volume-Filling Samples 92
        - Combined Horizons 92
    - Clod Labeling 92
      - Clod Tags and Box Labels-- 92

- 8 TRANSPORT TO THE PREPARATION LABORATORY 94
  - TRANSPORTATION OF BULK DENSITY CLODS 94
  - TRANSPORTATION OF BULK AND KNOWN-VOLUME SAMPLES 94

- 9 REFERENCES 95

- 10 CREW LOGBOOK FORMAT 96
  - CREW LOGBOOK 96
    - Instructions for Crew Logbooks 96

- 11 SCS-232 SITE AND SOIL PROFILE DESCRIPTION FORM 105
  - GENERAL GUIDELINES 105
  - PAGE ONE - CLASSIFICATION AND SITE INFORMATION 106
  - PAGE TWO - HORIZON DESCRIPTION 110
  - PAGE THREE - HORIZON DESCRIPTION (CONTINUED) 111
  - PAGE FOUR - HORIZON DESCRIPTION (CONTINUED) 112
  - COPY OF THE 232-FORM 114
  - CODESHEETS FOR 232-FORM 118
    - Site Codes 118
    - Site and Diagnostic Features Codes 119
    - Horizon Codes 120
    - Soil Taxonomy Classification Codes 123

FIGURES

Figure 6-1 Photogray Card 79
Figure 7-1 Blank DDRP Label A 88
Figure 7-2 Single Routine Sample - DDRP Label A 90
Figure 7-3 Single Field Duplicate - DDRP Label A 91
Figure 7-4 Field Audit Sample - DDRP Label A 91
Figure 7-5 Volume-Replacement Sample, DDRP Label A 92
Figure 7-6 Clod Tag 93
Figure 7-7 Clod Tag 93

TABLES

Table 4-1 Sampling Classes of Soils Mapped 70

ACKNOWLEDGEMENTS

The soil sampling protocols in this manual are based for the most part on the protocols described in the previous sampling manuals for the Direct/Delayed Response Project watershed surveys in the Northeast and Southern Blue Ridge Regions of the United States. Major contributions to the previous manuals were made by D.S. Coffey of NSI-Technology Services Corporation, Corvallis, Oregon; K.A. Cappo, formerly of Lockheed Engineering and Management Services Company, Inc., Las Vegas, Nevada; Kent Thornton of FTN, Inc.; and John Ferwerda. A special thanks goes to Carol Roberts for wordprocessing.

1 INTRODUCTION

This field sampling manual was written to guide personnel involved in the collection of soil samples for the US Environmental Protection Agency (USEPA) Direct/Delayed Response Project (DDRP) Mid-Appalachian watershed survey. All field personnel must be trained by persons knowledgeable in the procedures and protocols detailed in this manual.

The basic goals of the watershed survey are to map watershed attributes, to describe representative pedons, to collect representative soil samples without contamination, to preserve sample integrity for analysis, and to analyze samples correctly. Procedures have been chosen in an effort to balance data quality, the needs of the data users, and cost.

The objective of this manual is to emphasize and modify National Cooperative Soil Survey (NCSS) procedures, as is necessary, to describe and sample soils for the DDRP. This manual is written to an audience of soil scientists knowledgeable in NCSS procedures, with experience in soil description and soil sampling. Strict and uniform adherence to the sampling protocols described in this manual are essential to assure that soil data be comparable among pedons, watersheds and regions. Any deviation from the protocols must be documented in the field crew logbook and communicated to the Sampling Task Leader at the USEPA Environmental Research Laboratory in Corvallis, Oregon (ERL-C).

Selected watersheds are mapped to determine the spatial variability of soils, depth to bedrock, landuse, forest cover type, and drainage. Soils, identified in the mapping phase, are combined into sampling classes that are thought, or known, to be similar in properties that are important in determining the responses of surface waters (lakes, streams) to acidic deposition. This is done by soil scientists familiar with soils in each region, in conjunction with modelers and statisticians who will use the soil data. Each of the sampling classes is sampled across a number of watersheds in which it occurs. In this approach, a given soil sample does not represent the specific watershed from which it came; instead, it contributes to a set of samples which, collectively, represent a specific sampling class on all DDRP watersheds having soils in that sampling class.

2 FIELD PERSONNEL

FIELD CREWS

Each field crew consists of one crew leader who is a soil scientist experienced in NCSS procedures and 2 to 3 other crew members who may also be soil scientists. Crews from each state were numbered consecutively beginning with 01. For example, if West Virginia has two crews, they are WV01 and WV02.

The lead soil scientist in each crew supervises all field operations and decisions. This person is also responsible for selecting each sampling site and for documenting all field data. The field crew leader has the responsibility to:

- obtain soil samples from the sampling classes selected for characterization;
- make decisions concerning soil description and sampling including horizon delineation, horizon thickness, and material excluded from the samples;
- ensure that site and pedon descriptions, logbooks and labels are legible and accurate and that photographs are taken properly;
- ensure proper use and maintenance of field equipment, including cleaning between each sample;
- minimize contamination of samples particularly from soil or solution found above or below the horizon being sampled;
- maintain sample integrity (primarily by storage at 4°C) until shipping to the preparation laboratory;
- track sample shipment to assure that the correct number of samples have been shipped in the manner specified in these protocols;
- report to the Sampling Task Leader at ERL-C any problems or difficulties encountered while sampling or transporting soil samples at the earliest opportunity; and
- return all unused USEPA-issued field equipment and supplies to the State Soils Staffs for shipment to the USEPA.

SAMPLING TASK LEADER

The Sampling Task Leader from ERL-C has overall responsibility for the soil sampling activities and the QA program.

QUALITY ASSURANCE (QA)/QUALITY CONTROL (QC) PERSONNEL

The following personnel have responsibilities for auditing field crews to verify that all field activities were conducted using the protocols described in this manual. Evaluations must be discussed with field crews immediately following audits so that crews are aware of any potential problems. The QA/QC support personnel have the authority to resolve problems that may affect sample quality during audits. Written reports of the reviews will be documented and submitted by the auditors to the Sampling Task Leader at ERL-C within two weeks. Major problems must be reported orally within two days to the Sampling Task Leader.

USDA Soil Conservation Service (SCS), State Soils Staffs

A representative of each of the SCS State Soils Staffs will conduct a field methods evaluation for a minimum of one sampling site per field crew. Independent pedon descriptions are prepared by the State Soils Staff to assess soil variability at each site, to evaluate the differences in site descriptions among soil scientists, and to promote consistent application of soil concepts for describing pedons. The State Soils Staff must evaluate any differences between the crew's description and the independent description. If there are any discrepancies that might affect sample quality, then the profile descriptions must be discussed with the crew before sampling begins. This is to assure that samples are obtained from the appropriate depths and labeled with the correct horizon designations. Any changes made to the field crew's profile description must be documented on the description and the field crew logbook. The State Soils Staff representative will also monitor adherence to protocols for site selection, labeling, and sampling. The representative will make this assessment while the crew is describing and sampling the pedons. At the end of the audit all field operations including site location, profile description, and sampling will be discussed with the crew.

The State Soil Staffs are also responsible for assignment and supervision of crews, for reviewing all pedon descriptions forms (232-forms) at the end of sampling, and for return to the USEPA of supplies and equipment issued by the USEPA.

Regional Coordinator/Correlator (RCC)

The RCC must be a qualified soil scientist with extensive experience in soil profile description, mapping, and sampling. The RCC will monitor one site per field crew for adherence to NCSS standards, procedures, and for modifications to the sampling protocols presented in this document. The RCC will prepare independent soil descriptions using the same guidelines discussed above for the State Soils Staffs. The RCC will follow the same guidelines for audits as the SCS State Soils Staffs.

The RCC will monitor at least one site in each state in conjunction with the State Soil Staff representative; the remaining sites may be monitored independently. The RCC will ensure that State Soils Staff performs independent profile descriptions. During this process, the RCC will identify, discuss, and resolve any significant problems.

QA/QC Auditors

The DDRP QA Coordinator from ERL-C will lead QA/QC audits of field crews and a representative from EMSL-LV may participate in these audits. QA/QC audits will be conducted for each sampling crew once near the beginning of the sampling and once near the completion. The purpose of the audits is to evaluate the adherence to the sampling protocol specified in this manual and to identify and resolve any potential problems. Independent profile descriptions will not be prepared during these QA/QC audits.

3 FIELD EQUIPMENT

Materials marked with an asterisk (*) are supplied by the USEPA. Unmarked materials must be supplied by the crew. Equipment not specifically listed is considered optional. Permission must be obtained from the Sampling Task Leader before using optional equipment. It is the crew leader's responsibility to see that all USEPA-issued equipment and supplies are returned to the State Soils Staff for shipment to the USEPA upon completion of the sampling. This includes all durable equipment and unused consumables. Each crew must adapt this list to its area and prepare an equipment checklist to be used before proceeding into each sampling site.

SITE SELECTION EQUIPMENT

- screw auger
- bucket auger
- punch probe
- aerial photographs*
- stereoscope
- sharpshooter
- compass (adjustable for magnetic declination)
- topographic map
- map showing sampling sites (provided by ERL-C)*
- random number table*
- letter to landowner*

EXCAVATION EQUIPMENT

- shovels
- sharpshooter
- picks
- digging bars
- hand pump with discharge lines long enough to extend out of 2 m deep soil pits (Beckson Gusher - 16 GPM)*
- post hole digger
- backhoe

SOIL DESCRIPTION EQUIPMENT

- soil Profile Description Form (one per site)*
- logbook*
- clipboard
- Munsell color chart (newly purchased or in good condition)
- clinometer
- magnetic compass (adjustable for magnetic declination)
- hand lens
- hand knife
- pH kit*
- peat sampler (for Histosols)

- orange flagging*
- stake wire flags*
- indelible ink markers*
- golf tees, white (for horizon delineation in photographs)*
- water (for moist color and hand texture)

PHOTOGRAPHIC EQUIPMENT

- 35-mm camera, fully automated with flash*
- ASA-200 slide film
- prepaid film mailing envelopes
- photogray cards*
- khaki cloth measuring tape (5 cm x 2 m) with clearly marked figures at 50-cm intervals and tick marks at 10-cm intervals*
- slidefile, archive quality (for archiving slides)*

SAMPLING EQUIPMENT

- post hole digger (for Histosols only)
- 1 brass sieve (20-mm)*
- 2 - 1 3.5 L plastic buckets*
- spatula or knife (for sampling thin horizons)
- wire brush and paper towels (for cleaning sieves and plastic buckets)
- plastic inner bags (20/day)*
- cloth exterior bags (20/day)*
- DDRP Label A*
- 2 staplers*
- dust pan or dish
- hand trowel*
- garden trowel
- hole punch*
- bucket auger (only for special conditions)

CLOD SAMPLING EQUIPMENT

- Dow Saran-310® resin mixed with acetone*
- 3.5 liter metal paint can with lid (Saran storage)*
- hair nets (1/clod)*
- 6" x 8" Plastic bags, 1 mil (1/clod)*
- 17.50" x 11.94" x 3.75" Clod box, 24-cell (1 box/day-reusable)*
- 2" x 2" blank vinyl labels (attach to box to identify each clod compartment)*
- clod labeling tags with twist ties to close hairnets*
- rope (for hanging clods)
- clothespins, paperclips, or hooks (for hanging clods)
- hand knife
- scissors
- pruners

VOLUME-REPLACEMENT SAMPLING EQUIPMENT

- plastic graduated cylinder, 2 liter*
- plug to fit into cylinder*
- metal frame (8" x 8" x 2")*
- straight edge (ruler or edge of clipboard)
- garden trowel
- cheesecloth
- beads*
- plastic inner bags*
- cloth exterior bags (1 per horizon)*
- DDRP Label A*

VOLUME-FILLING SAMPLING EQUIPMENT

- 2 containers of known volume, 250 or 400 ml plastic beakers*
- straight edge (ruler or edge of clipboard)
- plastic inner bags*
- cloth exterior bags (1 per horizon)*
- garden trowel
- DDRP Label A*

TRANSPORTATION EQUIPMENT

- backpacks or, daypacks
- styrofoam coolers in cardboard boxes (3/day)*
- gelpacks*
- truck or car

SHIPPING EQUIPMENT

- styrofoam coolers in cardboard boxes (3/day)*
- strapping tape
- sample shipping forms, photocopy Crew Logbook - Sample Shipment Log page(s)*
- address labels to ERL-C (for sending copies of 232s and watershed maps with sampling site marked)*
- envelopes, 8.5 x 11 inch
- courier forms

4 SELECTION OF PEDONS TO BE SAMPLED

DEFINITIONS

The following definitions apply:

Sampling site:	A circle with a 150 m radius whose origin corresponds to one of the ordered points indicated on the watershed soil map supplied by ERL-C prior to sampling activities;
Potential sampling point:	A circle with a 5 m radius which can be searched for the preselected soil class and evaluated for the preselected vegetation class; and
Starting point:	A circle with a 5 m radius, centered at the same origin as the 150-m circle, which will be searched initially for the preselected soil class and evaluated for the preselected vegetation class.

IDENTIFYING A SUITABLE PEDON FOR SAMPLING

Soils (including inclusions) are grouped into soil sampling classes which are either known or expected to have similar chemical and physical characteristics for the purposes of the DDRP. The list of the soil sampling classes and information about the sampling classes are contained in Figure 1-3 of the main part of this report and the sampling classes of the map unit components that were mapped in this project are given in Table 4-1 of Appendix A.

Soil sampling sites are selected as locations where one would expect to find a combination of a pedon that represents a preselected soil sampling class and vegetation class. The sampling site locations are randomly selected from soil maps and vegetation maps of the DDRP watersheds.

Each sampling site is located within a map polygon having at least one map unit component of the desired sampling class, so that one would expect to find a soil pedon that fits the sampling class in the near vicinity of the randomly selected point. (Note: In a few cases, crews may be asked to sample a soil that occurs only as inclusions in a map unit). The pedon selected for sampling does not need to fit all the characteristics of a particular series, but must meet the criteria for the preselected sampling class.

If a pedon at a potential sampling point does not fit into the preselected sampling class, then this pedon is not sampled and the crew searches further for a pedon that would fit the selected

Table 4-1 Sampling Classes of Soils Mapped

Class	Map Unit Components
BMD	Ashe, Lordstown, Muskingum, Steinsburg, Sylco
BMK	Berks, Calvin, Calvin variant, Cataska, Catoctin, Dekalb, Gauley, Lehew, Mandy, Oquaga, Wallen
BND	Brandywine, Hazleton, Leetonia, Muskingum variant, Northcove, Shelocta variant, Tuckhannock, Tusquitee, Typic Dystrochrepts, Wyoming
BNS	Arnot, Cleveland, Klinesville, Ramsey, Sylvatus, Unicoi, Weikert
BXP	Chippewa, Morris, Norwich, Trussel, Volusta
BXW	Bath, Braceville, Lackawanna, Swartswood, Typic Fragiochrepts, Wellsboro, Wurtsboro
CFP	Atkins, Fluvaquents
CMS	Cedarcreek, Kaymine
FLW	Barbour, Basher, Codurus, Craigsville, Philo, Pope, Potomac, Sensabaugh, Udifluvents
HST	Carlisle, Lithic Medihemists, Palms
TPD	Armagh, Blairton, Cavode, Fenwick, Tygart, Zoar
TWD	Bedington, Clymer, Eubanks, Hartleton, Leck Kill, Lew, Meadowville, Minneville, Morrison, Myersville, Rayne, Shelocta, Shouns, Thurmont, Upshur, Wharton
TWM	Cateache, Gilpin, Highfield, Lily
TXP	Andover, Brinkerton, Nolo
TXW	Albrights, Buchanan, Cookport, Ernest, Kedron, Laidig, Meckesville, Monongahela, Simoda

sampling class. The field crew leader decides whether a soil is in the appropriate sampling class. A pedon is suitable for sampling if the pedon falls within the desired sampling class and if the surrounding vegetation falls within the specified vegetation class.

EVALUATION OF FOREST COVER TYPE FOR POTENTIAL SAMPLING POINTS

The forest cover for sampling must be evaluated for the entire landform that the potential sampling point is located in. For example, if a pedon is preselected to be sampled from a coniferous forest cover type but the random sampling point falls at the base of an isolated deciduous tree, the vegetation is suitable.

The crew leader makes the final decision whether the correct vegetation class is present. If uncertainty exists, the leader must evaluate how he/she would map the vegetation in the area around the sampling point at a 1:24,000 scale with minimum delineations of two acres for wetlands and hydric soils and six acres for other soils.

PROCEDURES FOR LOCATING A SUITABLE PEDON

General Guidelines

The field crew will proceed to a preselected starting point identified by ERL-C from watershed soil maps and use the following procedure to locate a suitable pedon. Field crews will locate sampling points on aerial photographs and/or topographic maps in order to find reference points or landforms to aid in locating starting points in the field. In instances where the terrain is not too rough and vegetation is sparse, pacing off distances from reference points may be possible for locating starting points.

Field crews must be sensitive to landowner concerns about trespass and possible restrictions on excavating on public land. Landowners and government agencies must be contacted for access before sampling. Crew leaders will be provided with letters to landowners from the DDRP Technical Director, requesting cooperation with the project. Local personnel may be helpful in persuading reluctant landowners to grant access permission.

Procedure

Document all site selection activities and observations in the site selection notes section of the crew logbook.

Step 1: USEPA will provide a map that clearly shows five preselected, ordered random points.

Step 2: Go to the starting point of the first potential sampling site indicated on the map. If that starting point is inaccessible, but some part of the sampling site is accessible, follow the procedure in Step 4 to select the location of the pedon for sampling. If the entire sampling site is inaccessible or unsuitable, note the reasons in the crew logbook and proceed to the second or next potential sampling site.

Some land use classes generally are not suitable for sampling. These classes include urban land, barren land, and waste disposal land. The crew leader decides if a sampling site is unsuitable. All such decisions with their rationale must be recorded in the crew logbook.

Step 3: If the starting point is accessible and fits the specified soil and vegetation classes, sample the pedon.

Step 4: If the starting point is accessible but does not contain the specified soil class or vegetation class, then the following site selection procedures are required:

- From a random-number table, select a random number between 1 and 8 (where 1=N, 2=NE, 3=E, 4=SE, 5=S, 6=SW, 7=W and 8=NW)
- Transect potential sampling points in 10 m intervals along a 150 m straight line in the chosen direction until the first occurrence of the proper combination of soil class and vegetation class is found. If a proper combination of soil class and vegetation class is not obtained after five transects, go to the next highest numbered potential sampling site on the list
- Record in the crew logbook the number of the starting point(s), the direction of each transect, the intervals (m) and observations. As accurately as possible, mark the location of the sampling point on the watershed map supplied by USEPA. Record in the notes section of the 232-form at the bottom of the first page the number of the starting point and the direction and distance to the site chosen to sample

- If none of the five potential sampling sites yields an accessible pedon with the specified vegetation class and soil class, record this information in the field notebook and call the Sampling Task Leader as soon as possible.

LOCATING SUITABLE PEDONS IN MAP UNIT INCLUSIONS

Where insufficient map polygons are available to sample a soil class where it occurs as a major map unit component, crews may be asked to sample from map units where the class occurs only as inclusions. The following criteria must be met for a pedon to be sampled from a map unit inclusion:

- the map unit must include inclusions that fit the required sampling class,
- the sampling class must make up at least 20 percent of the map unit,
- a pedon must be found that meets the constraints of the sampling class.

If a suitable pedon cannot be located near the first sample site, go to the next site.

5 PEDON EXCAVATION

In order to describe and sample a pedon as specified in this sampling manual, the field crew must excavate a pit that exposes at least one clean face that is a minimum of 1 m wide and 2 m deep or down to bedrock.

A decision as to which face to describe is made before excavation has started so that neither soil excavated from the pit, nor human activity disturbs the soil on that side. Avoid piling excavated soil or standing on the side of the pit that will be sampled. If the crew must return to the site at a later time, then the crew will clearly flag a path to the site.

Unstable Soils If soil is unstable and there is a danger to members of the crew, do not excavate a standard pit. Excavate the pit in standard form as deeply and safely as possible. After this, the crew leader decides how to further proceed in the excavation, description, and sampling.

STANDARD EXCAVATION

Pit Size

There are many methods available for excavating a sampling pit. The standard excavation method described in this subsection is practical in many soil sampling situations.

The preferred initial size of the pit is at least 1 m wide by 2 m deep or to bedrock. It is desirable to use these dimensions both to observe the soil throughout the range of its characteristics and to obtain representative samples; however, modifications of this method may be required to fit specific situations.

Steps in the Pit

When the pit is excavated, steps may be useful. The steps allow the field crew to continue digging a pit large enough for proper characterization of the pedon and they also allow access for describing and sampling the pedon.

EXCAVATION OF SOILS WITH WATER TABLES

Describing and sampling soils with high water tables may require special methods of excavation. A sump may be dug in a corner away from the face to be described and sampled. Water may be removed from the sump by bailing or pumping as necessary. It may be desirable to describe and sample lower horizons first in order to reduce contamination of the sample and minimize water removal effort.

Sumps may be dug upstream of the flow of the water table. Use a bucket auger, peat sampler, or other implement to dig a hole that will collect the flowing ground water before it enters the pit. In flat areas with no discernible direction of ground-water flow, it may be necessary to dig holes on all sides of the pit, in order to drain the local water table, before the pit can be described and sampled.

Soil pits in level terrain with a high water table are difficult to sample. If the previous options do not result in a clean, dry pedon face, allow the local water table to drain into the pit for a period of time while pumping continuously until the local water table is fairly well drained. Continue using the hand pump, directing its outflow away from the pit as much as possible. When the inflow of water is reduced to a manageable level, then describe and sample the pedon. As a last resort, a bucket auger or posthole digger may be used to sample very wet mineral soils. Document in the logbook and in the free form notes section of the 232-form if such tools are used for sampling.

EXCAVATION OF ORGANIC SOILS

Organic pedons cannot readily be excavated in standard form. As a result, organic pedons may be described using a peat sampler and sampled with a posthole digger.

SOILS DIFFICULT TO EXCAVATE

In cases where the C horizon material is extremely difficult to excavate, a depth of 0.5 m less than the specified depth, although not desirable, is acceptable. The field crew leader decides if the soil is too difficult to dig through. Document this decision on the 232-form in the free form notes section and in the crew logbook.

6 SITE AND PROFILE DESCRIPTION

Accurate and clear descriptions of site and soil characteristics are important to the DDRP soil survey. Descriptions provide data to assess soil variability, assignment of sampling classes, classification, correlation, and interpretation. Standards and guidelines are necessary for different observers to describe soils with precision and clarity. The NCSS guidelines for site and soil profile description guidelines and a glossary of landform and geologic terms are contained in the National Soils Handbook (NSH) (Soil Survey Staff, 1983). If the standard terminology is not appropriate, then write narrative descriptions of special features in the free form notes of the 232-form.

The description of a body of soil includes site characteristics, the types, depths and thickness of soil horizons, and the properties of each horizon. Site characteristics include location, geomorphology, vegetation, climate, erosion, runoff, flooding, ponding, and landuse. Horizon properties include color, texture, structure, consistence, the presence of roots, animals and their traces, reaction characteristics, coating on peds and characteristics of the boundaries between horizons.

The areas chosen for description and sampling are areas that previous mapping has shown to contain the soil types of interest. The pedon is usually selected on the basis of external evidence. Once a tentative sampling site is located, the soil is examined to verify that it is within the criteria for preselected sampling class.

Descriptions must be completed before sampling. Changes to descriptions may be made if they become evident during the sampling process. To observe horizontal relationships between soil features, expose a cross section of each layer by removing the soil above the layer. Each horizontal section must be large enough to expose any structural units. A great deal about a horizon is apparent when it is viewed from above, as well as from the pit face.

To record the field description, the field crew will use the SCS 232-form which is coded for easy input onto a computerized data file. The 232-form is reproduced along with instructions and codes in Section 11 of this appendix. Use vegetation codes from the National Handbook of Plant Names (SCS, 1981). Soils must be classified using Keys to Soil Taxonomy (Soil Survey Staff, 1988).

INDEPENDENT PROFILE DESCRIPTIONS

The SCS State Soils Staffs and the RCC will prepare independent profile descriptions of sites when auditing field crews. These descriptions describe the same face of the pit used by the field crews.

Before sampling begins, the Soils Staff and/or RCC will obtain the crew's description for comparison. If there are any discrepancies that might affect the quality of samples obtained, there will be a discussion about the descriptions before sampling proceeds. These discussions are useful to promote uniform concepts and terminology for soil descriptions. If the crew makes any change to its description as a result of such a discussion, then this must be documented completely on the 232-form and in the logbook. If the independent profile describers feel that there are no discrepancies that might affect sample quality, the discussion of the profile description will take place at the end of the audit when all field operations are reviewed.

PROFILE DESCRIPTION

Clean the sides of the pit of all loose material dislodged by digging the pit. Examine the entire exposed pit face. Identify significant differences in any soil chemical or physical properties that distinguish adjacent layers. Examine a profile with a perched or rising water table from the bottom up to avoid contamination. Use the white golf tees to mark the boundaries between horizons on the face of the pit. Identify and then describe the horizons. Photographic documentation will take place after the soil is described and before the pedon face is disturbed by sampling.

Sometimes a horizon or layer designated by a single letter or a combination of letters needs to be subdivided. The Arabic numerals used for this purpose always follow all letters (following the guidelines in the National Soils Handbook (Soil Survey Staff, 1983). Sampling crews need to be alert to taxonomic questions that may arise so they can sample and describe appropriately to resolve the questions (e.g., describe dry color if there might be a mollic or umbric epipedon, describe clay films if there might be an argillic horizon).

Horizons in the upper 1 m are split for sampling if they are more than 30 cm thick, excluding organic horizons. Uniform horizons below 1 m are split for sampling if they are more than 60 cm thick. Horizons split for sampling because of thickness are entered on the 232-form as more than one horizon.

The ideal sample contains each soil material within the horizon in proportion to its occurrence in the pedon. Horizons that have distinct parts of two kinds of master horizons (i.e., E/B, B/C) will be sampled to obtain portions of each material in proportion to its abundance in place. In this case, the relative proportions of each type of material must be recorded in the horizon notes of the 232-form (page 2). This type of situation must be documented in the free form notes of the 232 and the crew logbook.

A single horizon may contain several thin strata. When the thin contrasting strata cannot be readily separated for sampling, combine the strata into one sample for the horizon. Each soil material will be described and proportions recorded. The soil material will then be sampled in those proportions. Note stratified horizons in the free form notes on the 232. Section 11 includes detailed instructions for completing 232-forms and must be read by all crew members that work with this form.

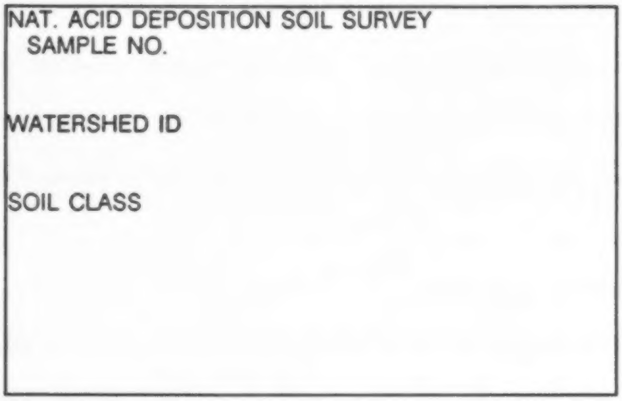
PHOTOGRAPHS OF PROFILE AND SITE

Photographic documentation of the sampling point and soil pedon is useful for later reference and to complement field descriptions. Field crews will be provided with a 35-mm camera. ASA-200 slide film will be purchased locally or provided by the State Soils Staffs. If tripods are available, they should be included in the photographic equipment. For film-quality consistency, all slides will be developed at Kodak laboratories.

Photographic documentation requires that a precise record be kept in the logbook to identify slides. Information concerning the slides must be recorded by the field crew in the logbook on the slide information form and in the LOG section of the 232-form.

Photograph in this order for each site sampled: pedon face, tree canopy above the pit, understory vegetation in the immediate vicinity of the pit, and representative landscape or landform.

Identify the pedon being photographed by filling out a photogray card (8.5 x 11 inch) provided (Figure 6-1) with the sample number (the "Site ID" from the 232-form), watershed ID and the sampling class. Place the photogray card at the top of the profile when taking the photograph. Holes can be punched on the left and right edges of the photogray card so that the card can be supported by stake wire flags. Note in the field logbook and the LOG section of the 232-form the order of the photos taken so the slides can be correctly labeled later. Place a khaki cloth measuring tape at the left side of the white golf tees so that depths correspond to horizon depths on the 232-form. Place an object for scale in understory vegetation photographs. Photograph organic pedons by sequential placement of the peat sampler increments on the ground or plastic and include the cloth picture tape in the photograph.



NAT. ACID DEPOSITION SOIL SURVEY
SAMPLE NO.

WATERSHED ID

SOIL CLASS

Figure 6-1 Photogray Card

In order to produce a quality slide, equal lighting of the whole pedon face is important. If some areas of the pit face are lit by full sunlight and others are shadowed by trees the slides will exhibit exposure problems and the boundaries between layers will be indistinguishable. If this problem arises, shade the entire pedon face for uniform exposure and use a flash. Natural sunlight and shaded photos are both necessary for adequate documentation. Try to avoid extremely oblique photo angles. The objective is to document the pedon and the site. Take as many photos as necessary to accomplish this goal.

Once the slides have been developed, they will be labeled on the slide mounts with the sample code, watershed ID, sampling class, and any other information the field crew deems necessary.

Slides are stored in 3-ring binders in archive quality slide files and are submitted with the logbook to ERL-C at the conclusion of the sampling phase of the survey. Use care in handling cameras and film. Avoid excessive heat and sunlight.

DOCUMENTATION

Crews must make two additional copies of their 232-forms and volume-replacement data forms (if using the metal frame). The originals must accompany a photocopy of the appropriate page(s) of the logbook sample shipment log in shipments of samples to the preparation lab in Las Vegas. One copy is sent to the Sampling Task Leader at ERL-C and one copy is given to the appropriate SCS State Soil Scientist Staff upon the completion of sampling. At the completion of sampling, the original crew logbook must be sent to the Sampling Task Leader at ERL-C and a copy forwarded to the SCS State Soils Staff.

7 FIELD SAMPLING PROCEDURES

IMPORTANT POINTS CONCERNING SOIL SAMPLING

The objective of field sampling is to collect one representative soil sample from each horizon that will yield a minimum of 2 kg of air dried soil material that passes a 2 mm sieve, and samples to measure soil bulk density.

The sample site must be free of road dust and chemical contamination. Record in the crew logbook all known applications of fertilizers, pesticides and/or other chemicals. Soil samples are collected from major horizons to bedrock or a depth of 2 m from freshly dug pits that expose a clean vertical face about 1 m wide.

Samples are taken from continuous horizons greater than 3 cm thick, including the C horizon if present. Discontinuous horizons or horizons less than 3 cm thick are sampled if the crew leader determines them to be significant. Collect three bulk density clods from each horizon sampled. When it is not feasible to obtain clods (e.g., organic and very friable horizons), the crew next attempts to collect two samples using the volume-replacement method. If this is not possible, volume-filling samples are obtained where appropriate. It is anticipated that at least one of these methods will work for all soils, and that volume-filling will be used only rarely.

SAMPLING PEDONS

Field Sampling Protocols

The DDRP soil sampling protocols are based on methods developed by the National Soil Survey Laboratory, Lincoln, Nebraska (Soil Survey Staff, 1984) for the NCSS. These methods have been adapted for the special requirements of the DDRP Soil Survey.

SAMPLE SIZE

Horizon sampling begins after the sampling site has been excavated, photographed, and described. A minimum of 2 kg of air dried soil material that passes a 2 mm sieve is necessary to complete all chemical and physical analyses. Therefore, a volume of approximately 3.5 L (about 5.5 kg) of mineral soil material that passes a 20 mm sieve is required. If the estimated volume of the 2 to 20 mm size rock fragments exceeds 45 percent, more sample is needed (2 kg for every 10 percent increase over 45 percent).

Two full sample bags of organic horizon material are requested in every case possible. It will be difficult to obtain one gallon of uncontaminated sample from a thin horizon (< 3 cm). If the crew leader determines that a thin horizon is significant and will be sampled, then as much soil material as possible will be collected, given time constraints, while maintaining the integrity of the sample.

SAMPLING PROCEDURES

General Guidelines

Horizons are sampled in a sequence that minimizes contamination, results in a representative sample, and is most practical. The soil profile description must be adjusted to describe any spatial variability or attributes observed during sampling that were not accounted for in the original description.

Generally, sampling from the top of a pedon to the bottom is most effective for obtaining samples and for bulk density methods. In the case of a pedon where a water table is present, sampling from the base of the pedon up may be most practical.

Bulk samples must represent the characteristics of the entire cross section of each horizon. Obtain samples from across the pit, staying in the same horizon and avoiding horizon boundaries. Extract soil material from the pedon, placing it on a pan or tray to inspect it for contamination before adding it to the rest of the sample. Contamination from adjacent horizons and large roots must be removed from the sample.

Sampling of Oi horizons is not necessary. Depending on the thickness of Oe and Oa horizons, they may be sampled separately or together. Thin surface layers may be sampled from an uncontaminated area within a few meters of the pedon.

Pass the bulk samples through a 20 mm sieve. Samples should be sieved directly into a clean 3.5 L bucket and then transferred to sample bags. Sieving samples into a 3.5 L bucket ensures that the correct amount of sample is obtained.

Collecting Bulk Samples

Three types of bulk samples are handled for this project - routine samples field duplicates and field audits. Routine samples are used for characterization of horizons. Field duplicates are duplicate horizon samples taken every third pedon per crew. They are compared to routine samples to assess the precision of laboratory data. In addition, sampling crews will carry into the field small bags of soil, known as field audit samples. These samples, which are sieved and rebagged between sampling other horizons, will help assess possible sources of contamination to samples. Field audits are prepared during sampling pedons with field duplicates (every third pedon).

Routine Samples–

Representative samples of horizons are obtained by collecting soil material from throughout horizons, avoiding material from horizon boundaries. Care must be taken to prevent contamination from other horizons. All tools and sieves must be cleaned before sampling each and every horizon. Use a wire brush to clean the sieve and tools. Wipe out the collection pans and buckets with paper towels.

Fill a plastic 3.5 L bucket with soil that has passed a 20 mm sieve, and transfer to a plastic sample bag. The actual amount of soil (< 2 mm) available for chemical analysis is highly dependent on the amount of coarse fragments contained in each horizon.

Label plastic sample bags with DDRP Label A. Attach the label to the bottom third of the bag, not near the top of the bag. Check that all designations are correct, complete, and legible. Do not include large, easily removed non-mineral material in the sample. Limit handling of the soil sample to avoid contamination. Excess water in histosols will be drained before sealing the sample bag. To prevent the loss of the fine particle size fraction do not drain water from bagged mineral soils.

Fold down the top of the plastic sample bag in approximately 2 cm sections. Staple the folded sections to seal the bag. With indelible ink, label a canvas bag on the bottom third with exactly the same information contained on DDRP Label A. Place the sealed plastic bag within the canvas bag. Seal the canvas bag by tying. Soil samples must be placed into a 4°C temperature storage area if not shipped within 24 hours. If a sampling crew is shipping the samples to the prep lab within 24 hours, storage within the coolers for transport is acceptable. See Section 8 for details about shipping samples.

If a crew spends longer than 24 hours in the field, frozen gel packs are necessary. Store as many frozen gel packs in one cooler as possible when transporting to the sampling site. This will keep the gel packs frozen longer. Place two gel packs in each cooler with samples. Placing more gel packs in coolers may freeze samples, which must be avoided.

Field Duplicates–

Each crew will obtain a duplicate sample from one horizon of every third pedon sampled. These field duplicate samples must be as identical to the routine samples as possible. Horizons must be randomly selected for duplicating without sampling any one type of master horizon more often. Crews must duplicate organic horizons at least once if they sample any organic horizons. Place or sieve alternate trowelfuls of soil from the pedon into two different containers. Field duplicates are bagged exactly the same way as routine samples.

Field Audit Samples–

The same day that crews collect field duplicates they also prepare field audit samples. USEPA provides the crews with 15 packages of 3 - 500 g bags of audit soil placed in one canvas bag with a partially completed DDRP Label A for each bag. Crews will carry these bags into the field where they will sieve and bag them as though they were routine samples. The packages of field audits are numbered and the last three packages are organic material. The packages must be used consecutively as they are numbered except when preparing organic field audits. The crew will attempt to prepare organic field audits during sampling pedons when a field duplicate is sampled. If this does not work out, then a package of organic field audits will be prepared the next time field duplicates and field audits are handled.

The first field audit sample is prepared after sampling the first horizon, the second mid-way down the profile and the last after the last horizon. Use the bags of audit soil in random order. To prepare field audit samples, clean all tools, sieves and containers as with routine samples. Sieve the field audit sample into the bucket, and then transfer it into a plastic sample bag. A partially completed DDRP Label A will be provided by the USEPA with each sample. Complete the blank portions of the DDRP Label A with information used for the rest of the pedon and include the depth of the horizon that preceded the field audit. Label a canvas bag with "Field Audits," the date sampled, crew ID, site ID and set ID. Place all three field audits in this canvas bag and tie shut. In the horizon notes, on page 2 of the 232-form, record the field audit sample codes and horizon designations in the spaces for each horizon that preceded the field audits.

Sampling for Bulk Density Determination

Bulk density is an important parameter for this project because all measurements that are made on a mass basis are multiplied by bulk density to convert to a volume basis. Special care and attention to detail are required to obtain quality bulk density measurements.

Clods are the preferred method for this survey; however, if clods cannot be obtained volume-replacement samples will be obtained. If volume-replacement samples cannot be obtained, then crews will use the volume-filling method. At the beginning of sampling, crews will collect both clods and volume-replacement samples for the first four horizons where clods can be sampled.

Clod Method–

Clods samples are intact volumes of soil that are placed into hairnets and then dipped in saran to coat them. This is a widely used method but it does not work well in soils that are loose or soils with a large amount of rock fragments.

Collect undisturbed natural clods (three per horizon) of about 200 cm^3 to 400 cm^3 in volume. Remove a chunk of soil larger than the desired size of clod from the face of a sampling pit with a spade or trowel. From this piece, prepare a clod by gently cutting or breaking off protruding peaks and material sheared by the spade. If roots are present, they can be trimmed with scissors or pruners. In some soils, the proper size clods can be removed directly from the face of the pit with a knife or spatula.

This procedure for taking samples will not fit all soils; the procedure must be adjusted to meet the conditions in the field at the time of sampling. If sampling fist sized clods is not possible, intact clods may be obtained that are slightly smaller in isolated cases. Avoid sampling clods that are smaller than 100 cm^3 because analyzing small clods gives a much greater likelihood of error than analyzing large ones.

Before sampling begins cut up sheets of clod labels and punch a hole in each tag at the left side of the labeling. Fill out each clod label before placing on the clod.

Place each individual clod in a hairnet, close the hairnet with a twist tie that has the clod tag on it. Suspend it from a rope hung out like a clothesline.

Dip each clod into the saran mixture momentarily (2 seconds). Avoid breathing in the fumes as they may be carcinogenic. One dip is recommended but more may be necessary to dip coat clod. Note the number of times a clod is dipped on the upper right hand corner of clod tag and on the horizon notes on page two of the 232-form. Allow the saran coated clods to dry for 15 minutes or until dry to touch.

Field Transport of Clods

Place clods in 6" x 8" plastic bags and place in the compartmentalized clod boxes. The top (inner face) of the clod box will be labeled with the small stick-on labels with the same information as on the clod tag and if the clod was dipped more than once. Take great care to ensure that the clods are not broken or damaged during handling and shipping. Fill space in each compartment occupied by the clods with packing material (i.e., leaves, grass, or extra plastic bags.)

Volume-Replacement Bulk Density Sampling–

When clods cannot be obtained the volume-replacement method is used. A level step is prepared in the soil pit at least large enough to dig two circular holes approximately 10 cm in diameter and 10 cm deep or to the boundary of the next lowest horizon. Larger diameter holes must be used for thin horizons. When a level step cannot be obtained a metal frame is used to provide a reference point for calibrating the surface roughness. All material (including roots) excavated from the small holes is placed into separate sample bags, paying careful attention to retain all of the sample.

The volume of the each hole is determined by lining the hole with cheesecloth by carefully pushing the material into all the irregularities of the hole. Fill a plastic graduated cylinder with beads. Record in the horizon notes of page two of the 232-form which sample is being measured (i.e. 1/2 for the first of two). Read the initial volume of the beads in the cylinder by placing the circular block into the cylinder and tapping the side twenty times (or more until large voids not visible) with a trowel handle. Record the initial volume on the 232-form as V_i. Fill the fabric lined hole with beads, tamping and then leveling them. Use a straight-edge to help judge when the hole is full. Record the final volume of beads in the cylinder as V_f. Remove the beads and repeat for the second hole.

Seal the plastic bags as instructed for routine samples and place all the volume-replacement samples for one horizon in a canvas bag that is labeled with "Volume-Replacement", date sampled, crew ID, site ID, and set ID.

Volume-Filling Bulk Density Sampling--

When the previous two bulk density methods do not work the volume-filling method is used. This method is reserved for material such as loose sand, which cannot maintain an excavation, or irregular surface horizons. Samplers fill plastic beakers of known volume as best they can to recreate the same packing as naturally found in the soil. Fill the container completely and strike off with a straight-edge. The material is carefully transferred to a plastic bag and labeled. Two samples will be taken each time this method is used. Seal the plastic bags as instructed for routine samples and place all the volume-filling samples for one horizon in a canvas bag that is labeled with "Volume-Filling," date sampled, crew ID, site ID, and set ID.

SAMPLE LABELING

Much of the information recorded on the canvas bags, DDRP label A, and the clod tags and labels can be pre-labeled the day before sampling of the pedon occurs; i.e., the date, crew ID, site ID, a portion of the sample code and the set ID. The crew leader must have the pedon site located or be fairly confident the site will be found. This pre-labeling will ensure legibility, especially in wet conditions, and free a sampling crew member for other tasks at the sampling site.

DDRP Label A

Figure 7-1 shows the DDRP Label A which is used to label all routine, field duplicate, field audit, volume-replacement and volume-filling samples.

DDRP LABEL A

Date Sampled: _ _ _ _ _ _ _
D D M M M Y Y

Crew ID: _ _ _ _

Site ID: _ _ _ _ _ _ _

Sample Code: _ _ _ _ _ _ _ _ - _ _ _ _

Horizon: _ _ _ Depth: _ _ _ - _ _ _ cm.

Set ID: _ _ _ _ _

Figure 7-1 Blank DDRP Label A

General Guidelines

Enter all zeros as Ø, left justify horizon and include leading zeros for depth. Be sure all entries are legible and have a crew member proofread the labels who is not filling them out.

Date

The sample date is entered in the format DD MMM YY. For example, October 14, 1988 is 1 4 O C T 8 8.

Crew ID

The crew identification (ID) consists of four digits: the first two are alphabetic, representing the state, and the second two are the crew number assigned to each field crew for the state. An example of a crew ID is WVO1.

Site ID

The site ID consists of up to 8 digits and appears on the watershed map with the sampling starting points. There are only 7 spaces on the label so if needed extend the last digit to the right. Note: this is not the same as what is called "Site ID" on the 232-form. Site ID from the 232-form is part of the sample code for the DDRP.

Sample Code

The sample code represents the sample type and the SCS soil code. The first 3 digits of the sample code represent the type of sample:

Routine sample codes begin with "R" (R11 = routine sample, 1 bag; R23 = routine sample, second of 3 bags):

- Field duplicate codes start with "FD" (FD0 = field duplicate, 1 bag; FD1, FD2 are used for multiple bags);
- Field audit codes are supplied by USEPA with the samples. Volume-replacement codes start with "VR" (VR0 = only one sample taken; VR1, VR2 = first and second samples);
- Volume-filling codes begin with "VF" (VF0 = one sample taken; VF1, VF2 = first and second samples).

Digits 4 through 11 are the SCS soil number which will be provided to crews before sampling (which is the "Site ID" from line 1 of the 232-form with 2 digits instead of 3 for "unit"). Digits 4 to 5 are the two letter state abbreviation, 6 to 8 are the SCS county code and digit 9 is a dash. Digits 10 and 11 are the county pedon number ("unit") and digits 12 and 13 are the horizon number (with a leading zero if < 10).

Horizon and Depth

The horizon and depth line contains the information described in the horizon designation and depth parameters of the 232-form. For field audit samples, the horizon designation is provided to crews with the sample code and the depth is the depth of the horizon that was sampled immediately prior to preparing the audit.

Set ID

The set ID is a four-digit number. A unique set ID number is used every day the sampling crew samples a pedon. The set IDs will be assigned for each crew by the USEPA. All samples, including field audits, are labeled with the same set ID for a given day.

Sample DDRP Label As--

Routine Samples

Figure 7-2 illustrates a completed label for a horizon that had one bag of routine sample taken for it. The county is number 017 in Pennsylvania. It is the third pedon sampled in that county this year and the sample is for horizon number 6. If two bags were collected because of rock fragment content or because it was an organic horizon, then the sample code would start with "R12" and "R22" for each of the two bags.

DDRP LABEL A
Date Sampled: 10OCT88

Crew ID: PA01

Site ID: 2A079071

Sample Code: R11PA017-0306

Horizon: C___ Depth: 095 - 120 cm

Set ID: 0299

Figure 7-2 Single Routine Sample - DDRP Label A

Field Duplicate Samples

Figure 7-3 illustrates how to label the field duplicate for the horizon in Figure 7.2. If two bags were collected because of rock fragments then the sample code would start "FD1" and "FD2" for each of the two bags.

DDRP LABEL A

Date Sampled: 1 0 O C T 8 8

Crew ID: P A 0 1

Site ID: 2 A 0 7 9 0 7 1

Sample Code: F D 0 P A 0 1 7 - 0 3 0 6

Horizon: C _ _ _ Depth: 0 9 5 - 1 2 0 cm
Set ID: 0 2 9 9

Figure 7-3 Single Field Duplicate - DDRP Label A

Field Audit Samples

Field audit samples are supplied to crews with the first three and the last two digits of the sample code and horizon designation already filled in by the USEPA. Field crews must fill in the Date Sampled, Crew ID, Site ID, the rest of the Sample Code (state, county, and unit number) and Set ID exactly the same as for all routine samples for that pedon. The Depth measurements that are filled in are the upper and lower depths of the horizon that was sampled immediately prior to handling that field audit sample. Figure 7-4 illustrates a DDRP Label A filled in for a field audit sample prepared after the horizon labeled in Figure 7-2.

DDRP LABEL A

Date Sampled: 1 0 O C T 8 8

Crew ID: P A 0 1

Site ID: 2 A 0 7 9 0 7 1

Sample Code: F A L P A 0 1 7 - 0 3 0 1

Horizon: C _ _ _ Depth: 0 9 5 - 1 2 0 cm

Set ID: 0 2 9 9

Figure 7-4 Field Audit Sample - DDRP Label A

Volume-Replacement and Volume-Filling Samples

Volume-replacement samples are labeled with "VR" as the first two digits of the sample code and volume-filling samples start with "VF." They are followed by "0" if only one sample could be obtained, "1" for the first of two samples and "2" for the second of two samples. Figure 7-5 shows a DDRP Label A filled out for the second of two volume-replacement samples taken.

Combined Horizons

If two horizons are combined, sample codes and horizon codes must be written on the DDRP label A for both horizons, i.e.,:

Sample Code: R12PA019-0302
R12PA019-03303

Horizon: Oe Depth: 000 - 00/0/02cm
Oa 002 - 000 cm

DDRP LABEL A

Date Sampled: 1 0 O C T 8 8

Crew ID: P A 0 1

Site ID: 2 A 0 7 9 0 7 1

Sample Code: V R 2 P A 0 1 7 - 0 3 0 6

Horizon: C _ _ _ Depth: 0 9 5 - 1 2 0 cm

Set ID 0 2 9 9

Figure 7-5 Volume-Replacement Sample, DDRP Label A

Clod Labeling

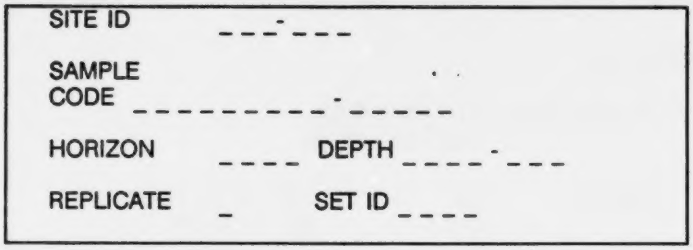
Clod Tags and Box Labels--

Clod tags are attached to clods in hairnets by punching a hole in the tags and putting a twist-tie through it. A clod tag is illustrated in Figure 7-6 Clod box labels are blank stick-on labels that are filled out with the same information as the clod tags. There are not enough blanks on the clod tag for the site ID so it is necessary to continue the code to the right of where the blanks end.

The first three digits of the sample code are "R11", followed by the same code as given to the routine sample(s) for the horizon. Horizon, depth and set ID are filled in just as for the other samples.

Replicates are labeled "1/3" (for the first of three clods), "2/3", and "3/3". If two clods are sampled they are labeled "1/2" and 2/2."

In the upper right hand corner of the tag write the number of times that the clod was dipped in saran (e.g., "1 dip"). Figure 7-7 is an example of a clod tag completed for the same horizon as Figure 7-2 for the second of 3 clods that was dipped twice in saran.



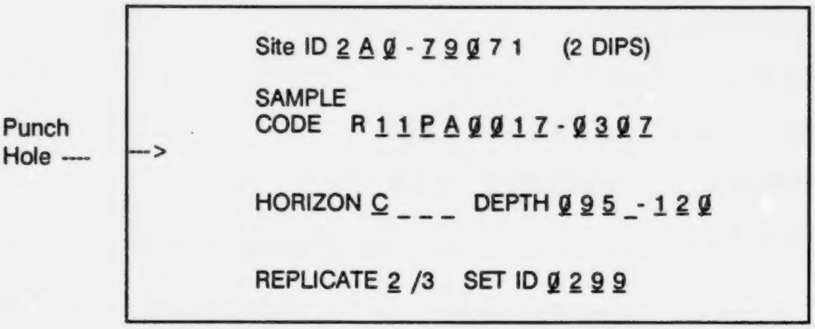
SITE ID ___-___

SAMPLE
CODE __________-_____

HORIZON ____ DEPTH ____-___

REPLICATE _ SET ID ____

Figure 7-6 Clod Tag



Site ID 2 A 0 - 7 9 0 7 1 (2 DIPS)

SAMPLE
CODE R 1 1 P A 0 0 1 7 - 0 3 0 7

HORIZON C ___ DEPTH 0 9 5 _ - 1 2 0

REPLICATE 2 /3 SET ID 0 2 9 9

Figure 7-7 Clod Tag

8 TRANSPORT TO THE PREPARATION LABORATORY

All samples and documentation are shipped to the preparation laboratory via overnight carriers. The carrier used for clod shipment may be different than that used for bulk samples and known-volume samples. The preparation laboratory must be notified if any shipments are made on Fridays.

TRANSPORTATION OF BULK DENSITY CLODS

Clods are easily broken in handling and every effort must be made to handle them carefully and pad them sufficiently when packing. Clods will be shipped to the preparation laboratory in Las Vegas via an overnight carrier to be specified later (which may be a different carrier than is used for bulk samples). Crews will wait until they have 2 or 3 clod boxes full of clods before shipping them. All the clods for a given pedon must be shipped at the same time.

Clods are shipped well padded in clod boxes that are placed in a styrofoam cooler and padded so they don't move around inside of the cooler. The coolers are shipped in cardboard boxes. Photocopies of the appropriate page(s) of the crew logbook, and sample shipment log will be placed in a 8.5" x 11" envelope which is placed inside a plastic bag and taped to the lid of the cooler. The clod boxes will be numbered so that the clods listed in the sample shipment log can be referenced to which box they are in. The outside cardboard box must be well sealed and reinforced with strapping tape made for packages.

TRANSPORTATION OF BULK AND KNOWN-VOLUME SAMPLES

Bulk samples and known-volume samples (volume-replacement and -filling) are shipped in styrofoam coolers with two frozen gel packs. The coolers are kept inside of cardboard boxes. Photocopies of the appropriate page(s) of the crew logbook, sample shipment log and the original 232-form(s) will be placed in a 8.5 x 11 envelope which is placed inside of a plastic bag and taped to the lid of the cooler. The outside cardboard box must be well sealed and reinforced with strapping tape made for packages.

9 REFERENCES

Soil Conservation Service. 1981. National Handbook of Plant Names. US Department of Agriculture, US Government Printing Office, Washington, DC.

Soil Survey Staff, 1988. Keys to Soil Taxonomy, (fourth printing). Soil Management Support Services technical monograph no. 6, Cornell University, Ithaca, N.Y.

Soil Survey Staff. 1984. Soil Survey Laboratory Methods and Procedures for Collecting Soil Samples. Soil Survey Investigations Report No. 1. US Department of Agriculture, US Government Printing Office, Washington, DC.

Soil Survey Staff. 1983. National Soils Handbook. US Government Printing Office, Washington, DC.

10 CREW LOGBOOK FORMAT

CREW LOGBOOK

Instructions for Crew Logbooks

Crew logbooks are important for documenting field activities. Crew leaders must make every effort to make thorough and clear logbook entries. Entries should be made in ink. The completed pages should be kept in looseleaf notebooks with dividers for the following sections:

- Cover Pages(s)
- Index Pages(s)
- Slide Key, Part I, Processing Information
- Slide Key, Part II, Slide by Slide
- Sample Shipment Log
- Site Selection Notes
- Soil Sampling Notes, Parts I and II

The Slide Key - Part II, Site Selection Notes and Soil Sampling Notes must be completed in the field. Sections of the rest of the logbook should be completed immediately after sampling. Separately number pages for each section consecutively. Use as many pages as necessary to fully document activities. The Sample Shipment Log must be completed for every shipment and photocopied to be sent with the shipment. The Soil Sampling Notes, Parts I and II, should be kept together for each pedon. Completing the table at the bottom of Soil Sampling Notes, Part I, is optional.

DDRP MID-APPALACHIAN SOIL SURVEY

COVER PAGE: _____
CREW ID: ________

CREW LOGBOOK

COVER PAGE(S)

Crew ID: _______________

Crew Leader: _______________

Crew Members: _______________

Additional Participants: _______________

Changes in Personnel: _______________

Comments: _______________

Sites Where Departed From Protocol or Special Circumstances:

Pedon Number(s)	Watershed Number(s)	Comments

Audit Visits:

WHO	DATE	Pedon Number	Watershed Number

DDRP MID-APPALACHIAN SOIL SURVEY

INDEX PAGE ____
CREW ID ________

CREW LOGBOOK

INDEX PAGE(S)

Pedon Number	Watershed ID Name	Sampling Class	Set ID	Date	Page(s)			
					Site Selection	Sampling Notes	Photo Notes	Shipping Notes

DDRP MID-APPALACHIAN SOIL SURVEY

SLIDE KEY - PART I PAGE:____
CREW ID: ________

CREW LOGBOOK

SLIDE KEY - PART I

PROCESSING INFORMATION

ROLL #	NUMBER SLIDES	KODAK PROCESSING NUMBER	CITY OF LAB	DATE MAILED	DATE RECEIVED	COMMENTS

DDRP MID-APPALACHIAN SOIL SURVEY

SLIDE KEY - PART II PAGE:____

CREW ID:________

CREW LOGBOOK

SLIDE KEY - PART II

SLIDE BY SLIDE

FILM ROLL #	SLIDE #	WATERSHED NUMBER	WATERSHED NAME	SLIDE DESCRIPTION

DDRP MID-APPALACHIAN SOIL SURVEY SHIPPING PAGE:____

CREW ID:________

CREW LOGBOOK SAMPLE SHIPMENT LOG

NAME & SIGNATURE OF PERSON RESPONSIBLE FOR SHIPMENT:__________________________

DATE OF SHIPMENT:______________ PLACE SHIPPED FROM:_______________________

CARRIER:_____________ TIME SHIPPED:________ NUMBER OF SHIPPING PAGES:_________

TOTAL NUMBER CANVAS BAGS:_______________ NUMBER 232s PACKED W. SAMPLES:_____

NUMBER OF BOXES SHIPPED:___________ NUMBER GEL-PACKS IN EACH COOLERS:_________

PEDON NUMBERS OF SAMPLES SHIPPED:_______________________________________

____

SAMPLES SHIPPED

SAMPLE CODES	HORIZON	BOX NUMBER	Comments (if clods write replicate numbers)

DDRP MID-APPALACHIAN SOIL SURVEY

SITE SELECTION PAGE:____

CREW ID:________

CREW LOGBOOK

SITE SELECTION NOTES

Crew Leader Initials:____

Watershed No:________________________ Pedon No:________________________

Watershed Name:______________________ County/State:____________________

Date:______ Preselected Sampling Class:_______ Vegetation:______________

Final Sampling Class:_______ Vegetation:______________

Numbers of Starting Points Used:________________________

Participants:____

____

Landowner:________________ Accessibility:______________________________

Notes: (starting point Numbers, observations at stops, transect direction & distance in m, comments)

DDRP MID-APPALACHIAN SOIL SURVEY SOIL SAMPLING, PART I/II PAGE:____
CREW ID:____

CREW LOGBOOK SOIL SAMPLING NOTES, PART I CREW LEADER INITIALS:____

Watershed No:________________________ Pedon No:__________________________

Watershed Name:______________________ County/State:_______________________

Date:______ Preselected Sampling Class:_______ Vegetation:______________
Final Sampling Class:_______ Vegetation:______________

Weather:____

Time of Arrival:____________________ Time of Departure:_____________________

Pit Excavation Notes:____

Sampling Class/Series Name Comments:____

Calculations and Rationale for Classification:______________________________

____

____

____

SAMPLES COLLECTED

HORIZON #	HORIZON DESIG.	# ROUTINE SAMPLES	# FIELD DUP'S	# CLODS	# VOLUME REPLAC	#1 Vi Vf	#2 Vi Vf	# VOLUME FILL.	COMMENTS

DDRP MID-APPALACHIAN SOIL SURVEY SOIL SAMPLING, PART I/II PAGE:____

CREW ID:________

CREW LOGBOOK SOIL SAMPLING NOTES, PART II CREW LEADER INITIALS:____

Watershed No:________________________ Pedon No:__________________________

Bulk Density Sample Notes: (methods, reasons for using, observations)

Miscellaneous Notes:____

Sample Transport and Storage Notes: (storage before shipping, etc)

11 SCS-232 SITE AND SOIL PROFILE DESCRIPTION FORM

Accurate and complete 232-forms are essential to document the exact site and soil characteristics, as well as to document important aspects or problems of sampling. The 232-forms must contain original field information. Thus, while it is permissible to recopy the forms later, all information must have been observed in the field. Official series descriptions should only be consulted for labeling a soil as a given series and not as a reference to consult for what the soil morphology and classification are "supposed to be."

GENERAL GUIDELINES

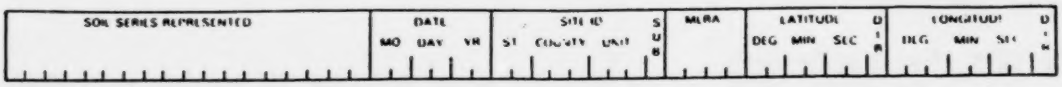
The information on the 232-forms will be entered into computers by non-soil scientists. This makes it crucial that everything be completed clearly and in full. The following rules are important:

- Entries that are letters or alphanumeric are left justified;
- Numbers are right justified;
- Zeros are entered as 0.

The 232-form and codes are reproduced at the end of this appendix.

Definitions of soil description terminology, landform and geologic terms are defined in the National Soils Handbook (NSH) (Soil Survey Staff, 1983).

PAGE ONE - CLASSIFICATION AND SITE INFORMATION



SOIL SERIES REPRESENTED	DATE			SITE ID			SUB	MLRA	LATITUDE			DIR	LONGITUDE			DIR
	MO	DAY	YR	ST	COUNTY	UNIT			DEG	MIN	SEC		DEG	MIN	SEC	

Soil Series Represented

The emphasis of this project is on soils that have been grouped into sampling classes. A pedon chosen for sampling does not have to meet the criteria of a given series. If a pedon fits a series closely but differs from the central concept of that series, use the following convention. If a pedon and the series are in different sampling classes, use the series name plus "var" for variant. If the pedon and the series are in the same sampling class, use the series name plus "tax" for taxadjunct. The series name "SND" is entered on the soil description when the crew leader feels that the soil does not fit into any established series or if they are uncertain which series it might be. The reason for labeling a pedon SND must be explained in the crew logbook and the 232-form.

Date

Fill in all blocks; for example October 5, 1988 would be 10 05 88.

Site ID

The two letter state abbreviation goes in the first two blocks, followed by the federal three number county code. The "unit" is the pedon number assigned by the SCS State Soil Scientist (right justified). This is not the same as the "Site ID" used by the USEPA to identify watersheds on the DDRP Label A.

MLRA

This is the numeric code for the MLRA that the site is in.

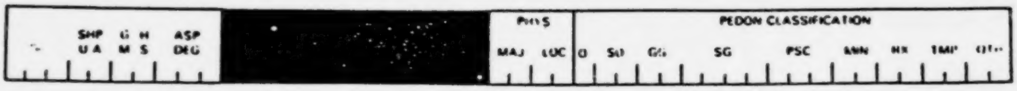
Latitude and Longitude

Do not enter the latitude or longitude. Mark the sampling point on the watershed map and submit it along with the 232. Cartographers at ERL-C will determine the exact latitude and longitude.

Second Row

This row is blocked out. It will not be completed.

Third Row



%	SHP		G	H	ASP		PHYS		PEDON CLASSIFICATION								
	U	A	M	S	DEG		MAJ	LOC	O	SO	GG	SG	PSC	MIN	HX	TMP	OTH

% (Percent Slope)

The percent slope of the sampling site is entered here (right justified).

SHP (Slope Shape)

Enter the slope shape for the sampling site under the "U" for up-and-down and "A" for across the slope.

GM (Geomorphic Component)

Crews must familiarize themselves with the definitions of the components given in the glossary of landform and geologic terms (Soil Survey Staff, 1983).

HS (Hillslope Component)

Use the terms as defined in the glossary of landform and geologic Terms, Part 607-NSH (Soil Survey Staff, 1983).

ASP. DEG. (Aspect in Degrees)

Enter the number closest to the measured aspect (corrected for magnetic declination) in degrees from the code sheet.

PHYS (Physiography); MAJ (Major Landform) and LOC (Local Landform)

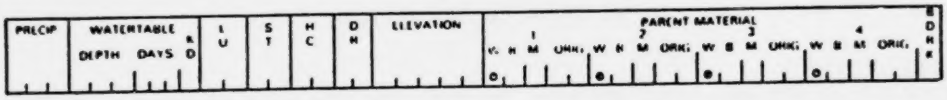
Use the terms as defined in the glossary of landform and geologic terms (Soil Survey Staff, 1983). Be consistent, e.g. if the major landform is mountains (MO) enter the local landform as mountainside (MO) not hillside (HS).

PEDON CLASSIFICATION

The pedon classification that is entered must be based on the field description and determined using Keys to Soil Taxonomy (Soil Survey Staff, 1988). Do not take the classification from the Official Series Description without keying it out for this specific pedon. The family particle size classification must agree with the field description. This means that the average rock fragment content and clay percent particle size control section should be calculated if appropriate. Taxonomic decisions and calculations must be recorded in the field crew logbook and in the free form notes of the 232.

The codes are organized by Great Groups (entered in the O to GG fields), Subgroups (SG), particle-size (PSC), mineralogy (MIN), reaction classes (RX), temperature regime (TMP) and other classes (OTH).

Fourth Row



PRECIP

Leave it blank and it will be filled in by the SCS State Offices.

WATERTABLE

DEPTH

Enter the depth (in cm to the watertable), if no watertable is observed then enter "0".

DAYS

Not used for this project.

KD (Kind)

Select the appropriate code from the code sheets. Leave blank if the kind is not known.

LU (Landuse)

Select the appropriate code from the code sheets.

ST (Stoniness)

Enter the number of the stoniness class of the site (0-5).

HC (Hydraulic Conductivity)

Enter the hydraulic conductivity (permeability) class from the code sheets.

DR (Drainage)

Enter the drainage class code from the code sheets.

Elevation

Leave blank, this will be filled in by cartographers at ERL-C.

Parent Material

Enter parent materials in order of abundance, most abundant first.

W (Weathering)

Not used for this project.

B (Bedrock Inclination)

Enter the appropriate code for inclination if known or relevant.

M (Parent Material Mode of Deposition)

Enter appropriate code. Definitions are in Glossary of Landform and Geologic Terms (Soil Survey Staff, 1985).

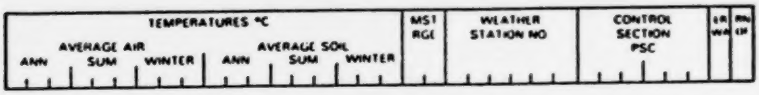
ORIG (Parent Material Origin)

Enter the most appropriate code. There is no specific code for metasedimentary. Use MS and make a note in the comments.

BDRK (Bedrock fracture)

If there is fractured bedrock enter the appropriate distance between fractures.

Fifth Row



TEMPERATURES °C						MST RGE	WEATHER STATION NO	CONTROL SECTION PSC	ER WA	RN OF
AVERAGE AIR			AVERAGE SOIL							
ANN	SUM	WINTER	ANN	SUM	WINTER					

TEMPERATURES

SCS State Office will fill out the average annual (ANN), summer (SUM), and winter air and soil temperatures.

MST RGE (Moisture Regime)

Enter the code for the moisture regime.

WEATHER STATION NO.

Leave blank.

CONTROL SECTION PSC

Enter in cm the particle size control section boundaries.

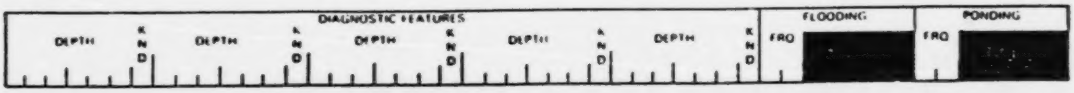
ERWA (Erosion Class)

Enter erosion class 1 (slight), Class 2 (moderate) to 3 (severe). This refers to current erosion.

RNOF (Runoff Class)

Enter the appropriate runoff class from the codesheet.

Sixth Row



DIAGNOSTIC FEATURES										FLOODING	PONDING
DEPTH	KND	DEPTH	KND	DEPTH	KND	DEPTH	KND	DEPTH	KND	FRQ	FRQ

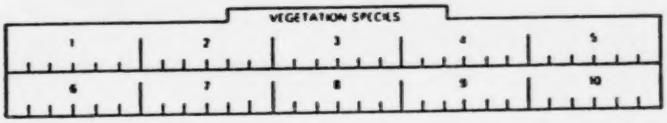
DIAGNOSTIC FEATURES

Carefully identify the diagnostic features and enter the upper/lower depths (cm) and the code for kind (KND) from the codesheet.

FLOODING, PONDING

Enter the code for frequency (FRQ) from the codesheet.

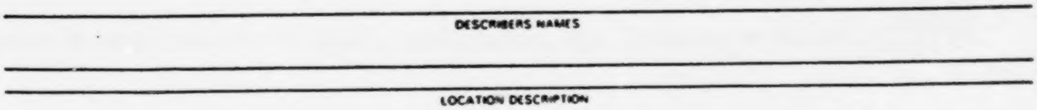
Seventh Row



VEGETATION SPECIES				
1	2	3	4	5
6	7	8	9	10

VEGETATION SPECIES

Enter abbreviations from the National Handbook of Plant Names (SCS, 1981) for the dominant vegetation in descending order of abundance. Record overstory vegetation first and then understory vegetation as space permits. Additional understory vegetation can be recorded on page 4 in the LOG section.



DESCRIBERS NAMES

LOCATION DESCRIPTION

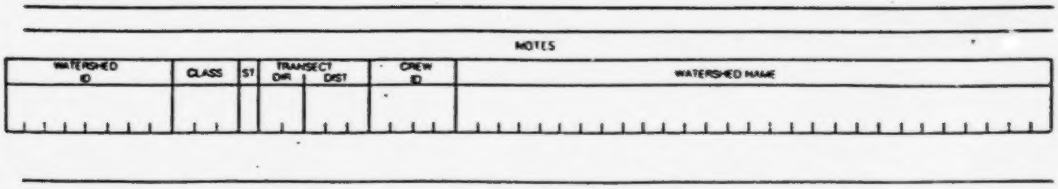
DESCRIBERS NAMES

Enter the names of the describers, starting with the crew leader.

LOCATION DESCRIPTION

Record the exact aspect in degrees in the free form location notes.

Eighth Row



NOTES

WATERSHED ID	CLASS	ST	TRANSECT DIR	TRANSECT DIST	CREW ID	WATERSHED NAME

WATERSHED ID

Enter watershed ID number as found on the site map supplied by USEPA.

CLASS

Enter the sampling class code.

ST (Starting Point)

Enter the number of the preselected random starting point used to locate the sampling site.

TRANSECT - DIR/DIST

Record the direction (N, NE, etc) and distance in meters of the transect taken from the random point used to the final sampling point.

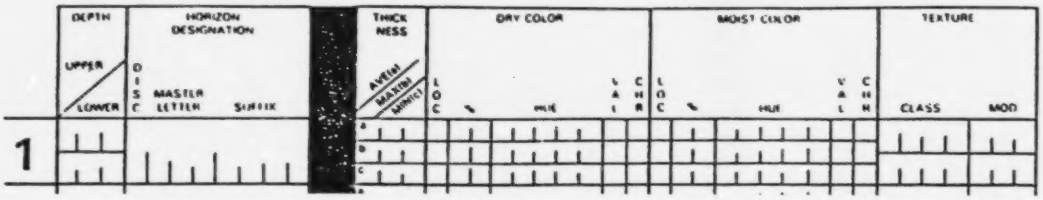
CREW ID

Crew ID	- use the actual crew ID code for the sampling crew
RCC	- for the Regional Correlator/Coordinator
SPA	- for SCS State Soils Staff Pennsylvania
SWV	- for SCS State Soils Staff West Virginia

WATERSHED NAME

Record the watershed name as it appears on the watershed map provided by the USEPA.

PAGE TWO - HORIZON DESCRIPTION



DEPTH
UPPER
LOWER
HORIZON DESIGNATION
DISC
MASTER LETTER
SUFFIX
THICKNESS
AVE(A)
MAX(B)
MIN(C)
DRY COLOR
LOC
%
HUE
VAL
CHR
MOIST COLOR
LOC
%
HUE
VAL
CHR
TEXTURE
CLASS
MOD
1

DEPTH

Enter the upper and lower depth in cm of the horizons.

HORIZON DESIGNATION

Enter separately, in the appropriate field, the number of any discontinuity (DISC), the master letter(s), and the suffix.

THICKNESS

Enter the average, maximum and minimum thickness of the horizon (cm), as can be observed across the width of the pit.

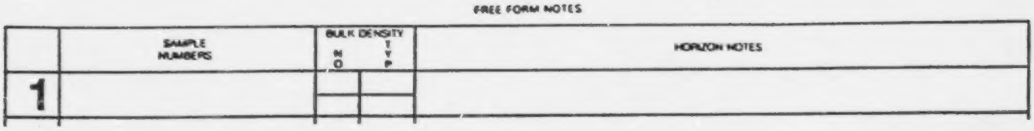
COLOR - DRY AND MOIST

Always enter the moist color and record the dry color in cases where it may be needed for classification (e.g. if the epipedon might be mollic or umbric).

Enter the color location code (LOC). If the soil is variegated, enter the percent (%) volume of each color.

TEXTURE

Enter the texture class code (including those for lithic and paralithic contacts and organic material) and the texture modifier code (MOD).



FREE FORM NOTES

	SAMPLE NUMBERS	BULK DENSITY		HORIZON NOTES
		NO	TYP	
1				

SAMPLE NUMBERS

Enter the sample numbers (including field duplicates) for the corresponding horizons. If field-audit samples are prepared, enter the sample code in the space for the horizon that preceded it.

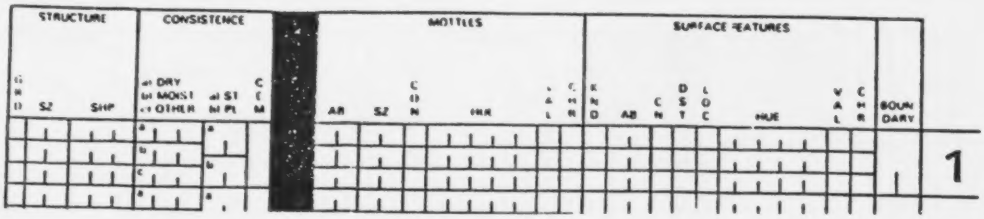
BULK (Bulk Density)

Enter the number (NO) and type (TYP) of bulk density samples taken for each horizon. Use C for clods, R for volume-replacement, and F for volume-filling.

HORIZON NOTES

If using the volume-replacement bulk density method, enter the replicate number (ie 1/2), the initial (V_i) and final (V_f) volume of the beads in the graduated cylinder. If using the volume-filling method, enter the volume of the container used. Include any miscellaneous notes that pertain to the collection of samples.

PAGE THREE - HORIZON DESCRIPTION (CONTINUED)



STRUCTURE			CONSISTENCE				MOTTLES						SURFACE FEATURES								BOUNDARY	
GRD	SZ	SHP	(a) DRY (b) MOIST (c) OTHER	(a) ST (b) PL	CEM		AB	SZ	CON	HUE	VAL	CHR	KND	AB	CN	DST	LOC	HUE	VAL	CHR		
			a	a																		1
			b																			
			c	b																		
			a	a																		

STRUCTURE

Describe the structure using the codes for grade (GRD), size (SZ), and shape (SHP) entered in descending order of abundance.

CONSISTENCE

Describe dry, moist or other consistence as completely as possible. Enter stickiness (ST), plasticity (PL), and cementation (CEM) codes as appropriate.

MOTTLES

Describe mottles, if present using the abundance (AB), size (SZ), contrast (CON) codes and the Munsell hue, value and chroma for colors.

SURFACE FEATURES

Use the codes on the codesheets to describe coatings, stains and slickensides. Enter kind (KND), abundance (AB), continuity (CN), distinctness, (DST), and location (LOC) and color as appropriate.

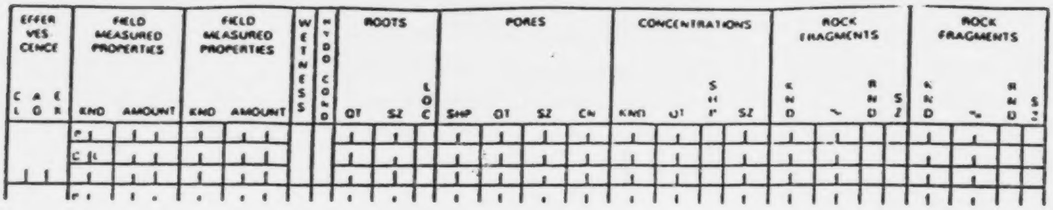
BOUNDARY

Enter the appropriate codes to describe lower boundary of the horizon.

FREE FORM NOTES

Fully document aspects of sampling, such as unusual features, sampling problems (e.g., why clods were not taken).

PAGE FOUR - HORIZON DESCRIPTION (CONTINUED)



EFFERVESCENCE			FIELD MEASURED PROPERTIES		FIELD MEASURED PROPERTIES		WETNESS	HYDO COND	ROOTS			PORES				CONCENTRATIONS				ROCK FRAGMENTS				ROCK FRAGMENTS			
CL	AG	EX	KND	AMOUNT	KND	AMOUNT			QT	SZ	LOC	SHP	QT	SZ	CN	KND	QT	SHP	SZ	KND	%	RND	SZ	KND	%	RND	SZ
			P																								
			CL																								

EFFERVESCENCE (Effervescence)

Not used.

FIELD MEASURED PROPERTIES

Use this field to enter the pH, using the kind (KND) from the codesheet and the amount, omitting the decimal point and right justified. Record the estimated clay percent (CL).

WETNESS

Enter the code for soil wetness at the time of description.

HYDO COND (HYDRAULIC CONDUCTIVITY)

Enter the code for the hydraulic conductivity for the horizon being described.

ROOTS

Describe roots using the codes for quantity (QT), size (SZ) and location (LOC).

PORES

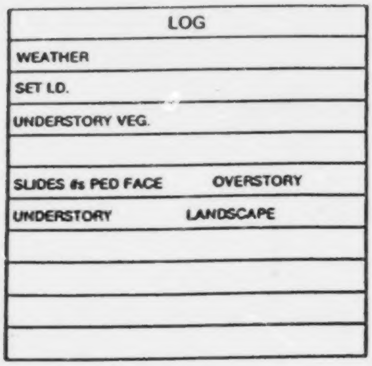
Describe pores using the codes for shape (SHP), quantity (QT), size (SZ) and continuity (CN).

CONCENTRATIONS

Describe any appropriate concentrations using the codes for kind (KND), quantity (QT), shape (SHP) and size (SZ).

ROCK FRAGMENTS

Carefully describe rock fragments using the codes for kind (KND), the volume percent (%), roundness (RND) and size (SZ).

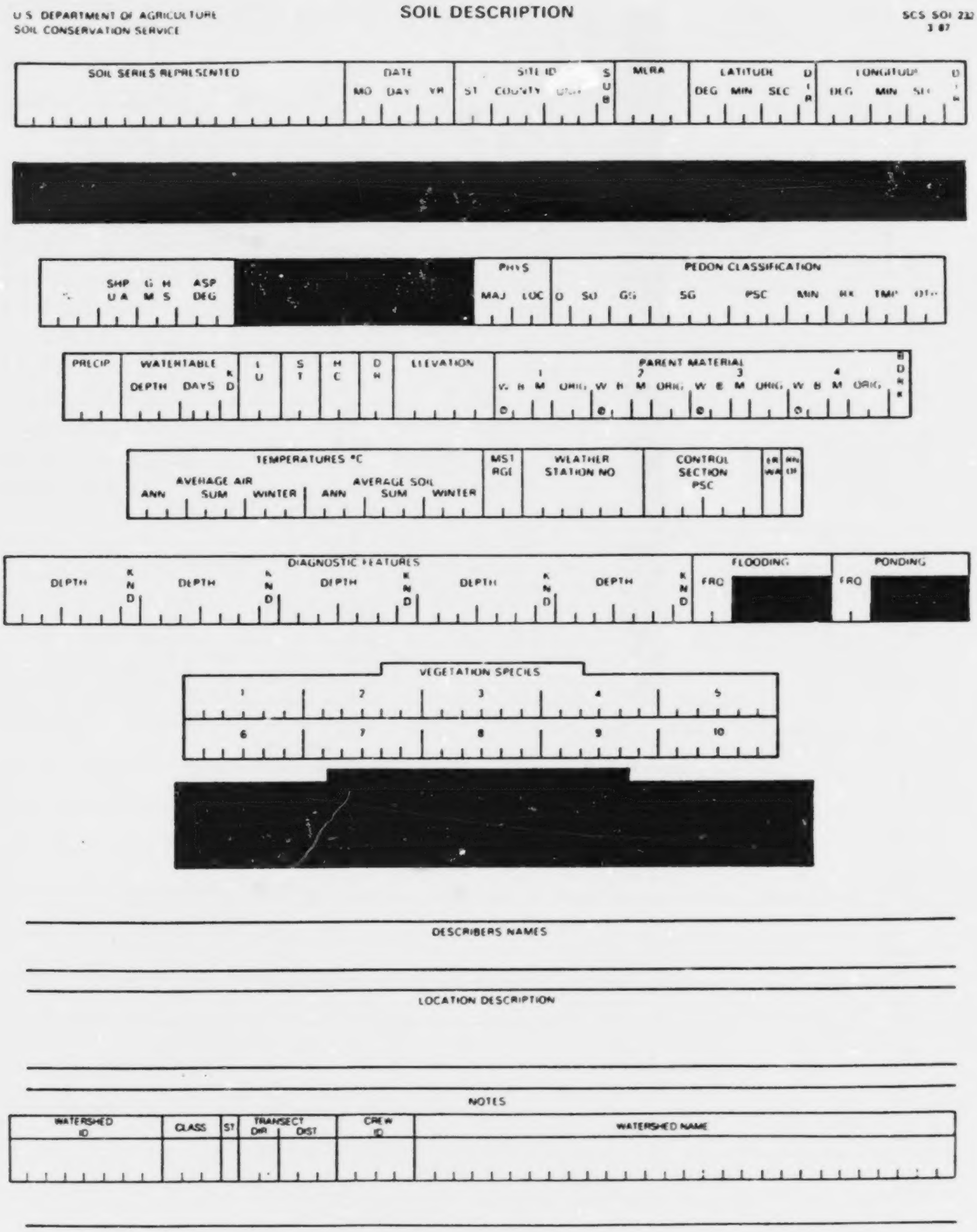


LOG	
WEATHER	
SET I.D.	
UNDERSTORY VEG.	
SLIDES #s PED FACE	OVERSTORY
UNDERSTORY	LANDSCAPE

LOG

WEATHER	Brief description of weather, e.g. "hot, drizzling."
SET I.D.	Provided to crews by USEPA.
UNDERSTORY VEGETATION	Enter understory vegetation that was not entered on page 1.
SLIDE #s	Enter the slide numbers for the pedon face, overstory, understory and landscape.

COPY OF THE 232-FORM
Page One - Classification and Site Information



U S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL DESCRIPTION

SCS SOI 232
3 87

SOIL SERIES REPRESENTED	DATE MO DAY YR	SITE ID ST COUNTY [illegible]	S U B	MLRA	LATITUDE DEG MIN SEC	D I R	LONGITUDE DEG MIN SEC	D I R

[redacted]

%	SHP U A	G M	H S	ASP DEG	[redacted]	PHYS MAJ	LOC	PEDON CLASSIFICATION O	SO	GG	SG	PSC	MIN	RX	TMP	OTH

PRECIP	WATERTABLE DEPTH DAYS	K D	I U	S T	H C	D R	ELEVATION	PARENT MATERIAL 1 W B M ORIG	2 W B M ORIG	3 W B M ORIG	4 W B M ORIG	B D R K

TEMPERATURES °C AVERAGE AIR ANN	SUM	WINTER	AVERAGE SOIL ANN	SUM	WINTER	MST RGI	WEATHER STATION NO	CONTROL SECTION PSC	ER WA	RN OF

DIAGNOSTIC FEATURES DEPTH	K N D	DEPTH	K N D	DEPTH	K N D	DEPTH	K N D	DEPTH	K N D	FLOODING FRQ	[redacted]	PONDING FRQ	[redacted]

VEGETATION SPECIES

1	2	3	4	5
6	7	8	9	10

[redacted]

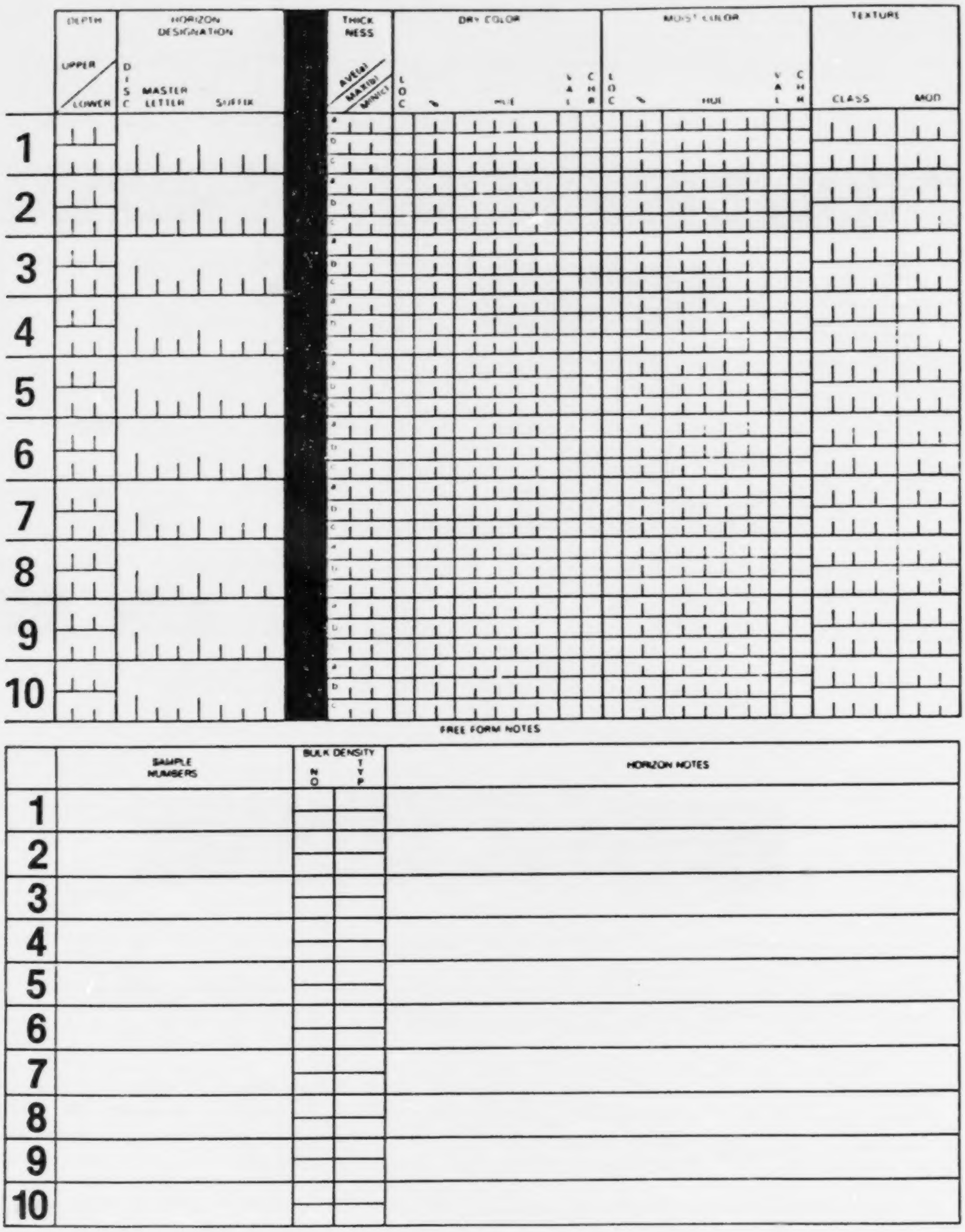
DESCRIBERS NAMES

LOCATION DESCRIPTION

NOTES

WATERSHED ID	CLASS	ST	TRANSECT DIR	DIST	CREW ID	WATERSHED NAME

COPY OF THE 232-FORM (continued)
Page Two - Horizon Description

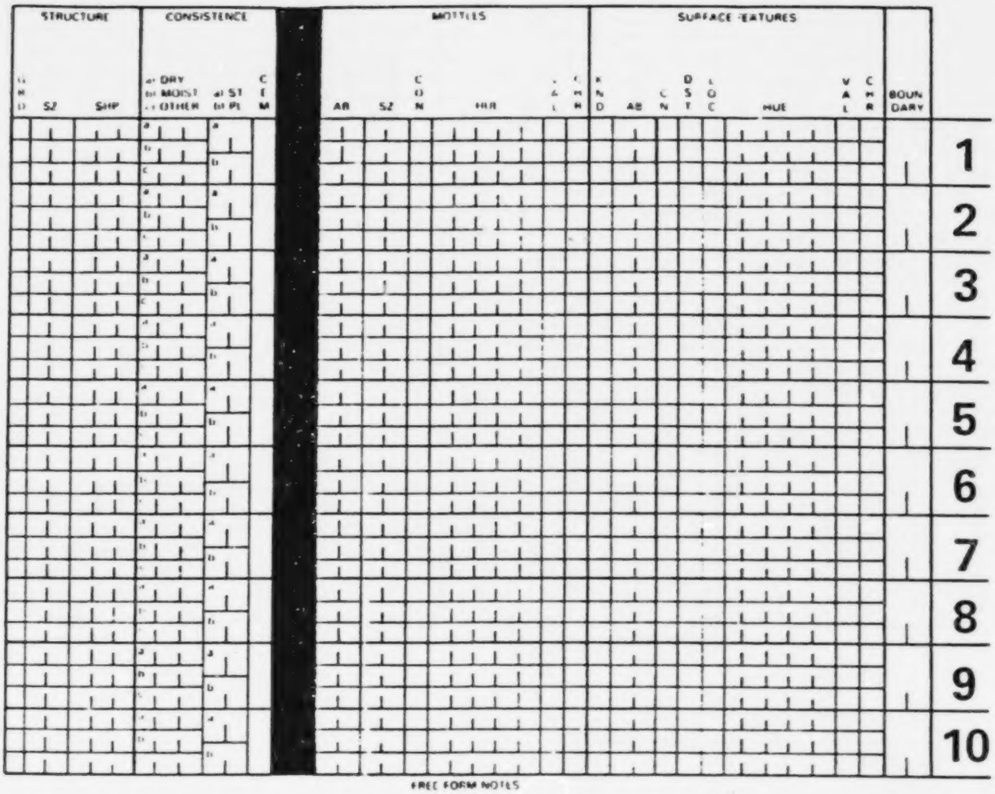


	DEPTH		HORIZON DESIGNATION			THICKNESS	DRY COLOR					MOIST COLOR					TEXTURE	
	UPPER	LOWER	DISC	MASTER LETTER	SUFFIX	AVE(a) MAX(b) MIN(c)	LOC	%	HUE	VAL	CHR	LOC	%	HUE	VAL	CHR	CLASS	MOD
1						a b c												
2						a b c												
3						a b c												
4						a b c												
5						a b c												
6						a b c												
7						a b c												
8						a b c												
9						a b c												
10						a b c												

FREE FORM NOTES

	SAMPLE NUMBERS	BULK DENSITY		HORIZON NOTES
		NO	TYP	
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

COPY OF THE 232-FORM (continued)
Page Three - Horizon Description (continued)

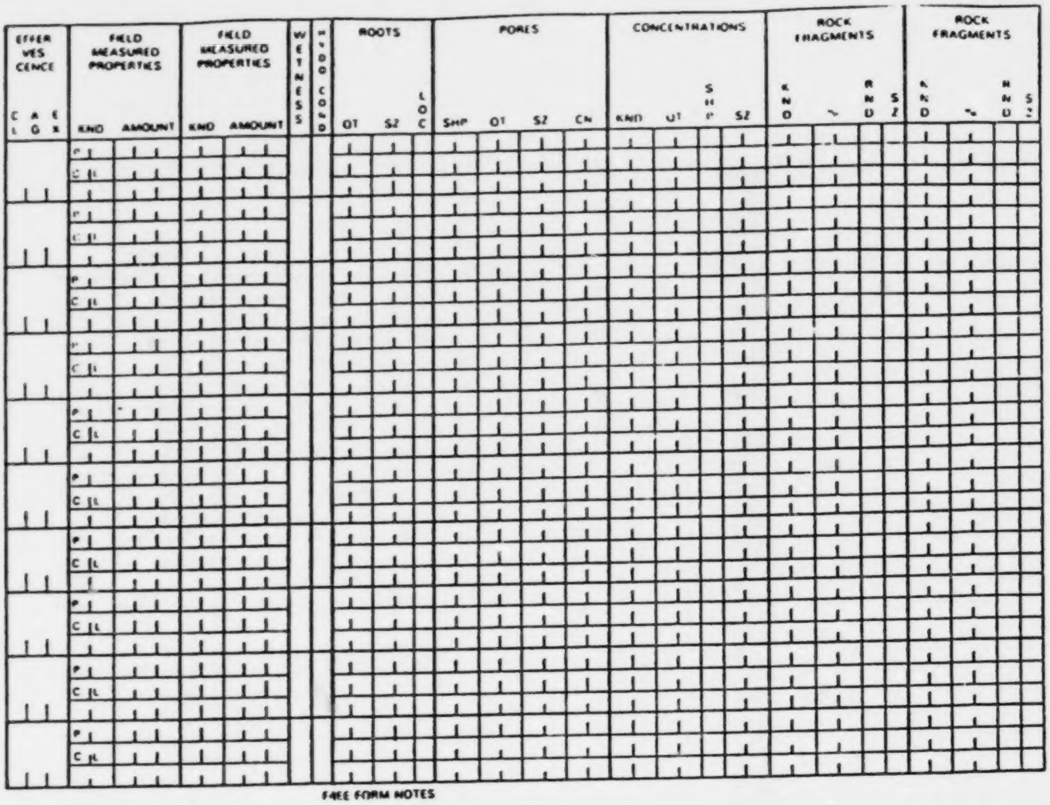


STRUCTURE			CONSISTENCE			MOTTLES						SURFACE FEATURES									
GRD	SZ	SHP	(a) DRY (b) MOIST (c) OTHER	(a) ST (b) PL	CEM	AB	SZ	CON	HUE	VAL	CHR	KND	AB	CN	DST	LOC	HUE	VAL	CHR	BOUNDARY	
			a b c	a b																	1
			a b c	a b																	2
			a b c	a b																	3
			a b c	a b																	4
			a b c	a b																	5
			a b c	a b																	6
			a b c	a b																	7
			a b c	a b																	8
			a b c	a b																	9
			a b c	a b																	10

FREE FORM NOTES

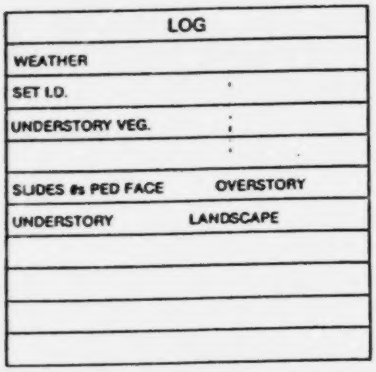
COPY OF THE 232-FORM (continued)

Page Four - Horizon Description (continued)



EFFERVESCENCE			FIELD MEASURED PROPERTIES		FIELD MEASURED PROPERTIES		WETNESS	HYDO COND	ROOTS			PORES				CONCENTRATIONS				ROCK FRAGMENTS				ROCK FRAGMENTS			
CL	AG	EX	KND	AMOUNT	KND	AMOUNT			QT	SZ	LOC	SHP	QT	SZ	CN	KND	QT	SHP	SZ	KND	%	RND	SZ	KND	%	RND	SZ
			P																								
			C																								
			P																								
			C																								
			P																								
			C																								
			P																								
			C																								
			P																								
			C																								
			P																								
			C																								
			P																								
			C																								
			P																								
			C																								
			P																								
			C																								
			P																								
			C																								

FREE FORM NOTES



LOG	
WEATHER	
SET I.D.	
UNDERSTORY VEG.	
SLIDES #s PED FACE	OVERSTORY
UNDERSTORY	LANDSCAPE

CODESHEETS FOR 232-FORM
Site Codes

SITE CODES

Slope Shape (U/A)

1	convex
2	plane
3	concave
4	undulating
5	complex

Geomorphic Component (GM)

1	interfluve
2	head slope
3	side slope
4	nose slope

Hillslope Component (HS)

1	summit
2	shoulder
3	back slope
4	foot slope
5	toe slope

Slope Aspect (ASP)

45	northeast
90	east
135	southeast
180	south
225	southwest
270	west
315	northwest
0	north

Major Landform (MAJ)

BA	Badlands
BI	Barrier Island
BO	Bolson
CA	Canyon
CF	Coalescent Fan Piedmont
CP	Coastal Plain
DF	Drumlin Field
DP	Deeply Disected Plateau
FH	Foothills
GF	Glaciofluvial Landform
GU	Glaciated Upland
HH	High Hills
HI	Hills
KP	Karst Plain
LP	Lake Plain
LU	Level or Undulating Upland
LV	Lava Plain
MO	Mountains
MV	Mountain Valley
PI	Piedmonts
PL	Plains
PT	Plateau
RV	River Valley
SB	Semibolson
SH	Sandhills
TA	Tableland
VM	Volcanic Mountains

Local Landform (LOC)

AF	Alluvial Fan
AP	Alluvial Flat (plain)
BE	Beach
BF	Barrier Flat
BO	Bog
BS	Backswamp
BT	Beach Terrace
BU	Butte
CB	Carolina Bay
CO	Cove
CR	Crater
CU	Cuesta
DE	Delta
DO	Dome
DR	Drumlin
DU	Dune
EK	Esker
EM	End Moraine
ES	Escarpment
FE	Felsenmeer
FP	Flood Plain
FT	Fluvial Terrace
FJ	Fjord
GM	Ground Moraine
HO	Hogback
HS	Hillside
KA	Kame
KE	Kettle
LS	Low Sand Ridge
LT	Lake Terrace
MA	Marsh
ME	Mesa
MO	Mountainside
MT	Marine Terrace
OP	Outwash Plain
OT	Outwash Terrace
OX	Oxbow
PE	Pediment
PL	Playa
RI	Ridge
SB	Structural Bench
SI	Sink
SL	Slough
SM	Salt Marsh
SW	Swamp
VC	Volcanic Cone
VS	Valleyside

Kind of Watertable (KD)

0	none
2	perched
3	apparent
4	ground

Land Use (LU)

A	abandonded cropland
C	cropland
E	forest land grazed
F	forest land not grazed
G	pasture land and native pasture
H	horticultural land
I	cropland irrigated
J	hayland
L	waste disposal land
N	barren land
O	other
P	rangeland grazed
Q	wetlands drained
R	wetlands
S	rangeland not grazed
T	tundra
U	urban and built-up land

Stoniness Class (ST)

0	class 0
1	class 1
2	class 2
3	class 3
4	class 4
5	class 5

Hydraulic Conductivity Class (HC)

1	very slow
2	slow
3	moderately slow
4	moderate
5	moderately rapid
6	rapid
7	very rapid

Drainage Class (DR)

1	very poorly drained
2	poorly drained
3	somewhat poorly drained
4	moderately well drained
5	well drained
6	somewhat excessively drained
7	excessively drained

Parent Material Weathering (W)

1	slight
2	moderate
3	strong

Bedrock Inclination (B)

1	< 5 degree inclination
2	5-30 degree inclination
3	> 30 degree inclination

Site and Diagnostic Features Codes

Parent Material Mode of Deposition (M)

A	alluvium
D	glacial drift
E	eolian
F	mine spoil and earth fill
G	glacial outwash
H	volcanic ash
I	lacustrine sands
J	lacustrine silts
K	lacustrine clays
L	lacustrine
M	marine
N	marine sands
O	organic
P	marine silts
Q	marine clays
R	solid rock
S	eolian-sand
T	glacial till
U	unconsolidated sediments
V	local colluvium
W	loess
X	residuum
Y	solifluctate
Z	estuarine

Parent Material Origin (ORIG)

A0	sandstone unspecified
A1	sandstone-noncalcareous
A2	arkosic-sandstone
A4	sandstone-calcareous
B0	interbedded sedimentary unspecified
B1	limestone-sandstone-shale
B2	limestone-sandstone
B3	limestone-shale
B4	limestone-siltstone
B5	sandstone-shale
B6	sandstone-siltstone
B7	shale-siltstone
C0	conglomerate unspecified
C1	conglomerate-noncalcareous
C2	conglomerate-calcareous
E0	ejecta-ash unspecified
E1	acidic-ash
E2	basic-ash
E3	basaltic-ash
E4	andesitic-ash
E5	cinders
E6	pumice
E7	scoria
E8	volcanic bombs
H0	shale unspecified
H1	shale-noncalcareous
H2	shale-calcareous
H3	shale-clay
I0	igneous unspecified
I1	igneous-coarse (or intrusive)
I2	igneous-basic (eg., gabbro)
I3	igneous-intermediate (eg., diorite)
I4	igneous-granite
I5	igneous-fine (or extrusive)
I6	igneous-basalt
I7	igneous-andesite
I8	igneous-acid (eg., rhyolite)

Parent Material Origin (cont.)

I9	igneous-ultrabasic
K0	organic unspecified
K1	mossy material
K2	herbaceous material
K3	woody material unspecified
K4	wood fragments
K5	logs and stumps
K6	charcoal
K7	coal
L0	limestone unspecified
L1	chalk
L2	marble
L3	dolomite
L4	limestone-phosphatic
L5	limestone-arenaceous
L6	limestone-argillaceous
L7	limestone-cherty
M0	metamorphic unspecified
M1	gneiss unspecified
M2	gneiss-acidic
M3	gneiss-basic
M4	serpentine
M5	schist unspecified
M6	schist-acidic
M7	schist-basic
M8	slate
M9	quartzite
P0	pyroclastic unspecified
P1	tuff unspecified
P2	tuff-acidic
P3	tuff-basic
P4	volcanic breccia unspecified
P5	breccia-acidic
P6	breccia-basic
P7	tuff-breccia
P8	aa
P9	pahoehoe
S0	sedimentary unspecified
S1	marl
S2	glauconite
T0	siltstone unspecified
T1	siltstone-noncalcareous
T2	siltstone-calcareous
Y0	mixed unspecifed
Y1	mixed-noncalcareous
Y2	mixed-calcareous
Y4	mixed-igneous-metamorphic & sed.
Y5	mixed-igneous & metamorphic
Y6	mixed-igneous & sedimentary
Y7	mixed-metamorphic & sedimentary
MS	meta-sedimentary

Bedrock fracture (BDRK)

1	< 10 cm between fractures
2	10 to 45 cm between fractures
3	45 cm to 1.0 m between fractures
4	1.0 to 2.0 m between fractures
5	> 2.0 m between fractures

Moisture Regime (MST RGE)

AQ	aquic
AR	aridic
PA	peraquic
PU	perudic
TO	torric
UD	udic
US	ustic
XE	xeric

Erosion Class (ER WA)

0	none
1	slight
2	moderate
3	severe

Runoff Class (RN OF)

1	none
2	ponded
3	very slow
4	slow
5	rapid
6	moderate
7	very rapid

Diagnostic Features (KND)

A	anthropic
B	cambic
C	calcic
D	durinodes
E	petrocalcic
F	fragipan
G	gypsic
H	histic
I	sombric
J	petrogypsic
K	placic
L	lithic contact
M	mollic
N	natric
O	ochric
P	plaggen
Q	albic
R	argic
S	spodic
T	argillic
U	umbric
V	sulfuric
W	paralithic contact
X	oxic
Y	salic
Z	duripan
1	kandic

Flooding and Ponding, frequency

NO	none
RA	rare
OC	occasional
FR	frequent
CO	common

Horizon Codes

HORIZON CODES

Color location (LOC)

0	not given
1	interior
2	exterior
3	crushed
4	dithionite-citrate pretreated
5	after exposure to air
6	after ignition
7	pyrophosphate extract

Texture class (CLASS)

C	clay
CE	coprogenous earth
CIND	cinders
CL	clay loam
COS	coarse sand
COSL	coarse sandy loam
CSCL	coarse sandy clay loam
DE	diatomaceous earth
FB	fibric material
FM	fragmental material
FS	fine sand
FSL	fine sandy loam
G	gravel
GYP	gypsiferous earth
ICE	ice or frozen soil
L	loam
LCOS	loamy coarse sand
LFS	loamy fine sand
LS	loamy sand
LVFS	loamy very fine sand
MARL	marl
MPT	mucky peat
MUCK	muck
OPWD	oxide protected weathered bedrock
PDOM	partially decomposed organics
PEAT	peat
S	sand
SC	sandy clay
SCL	sandy clay loam
SG	sand and gravel
SI	silt
SIC	silty clay
SICL	silty clay loam
SIL	silt loam
SL	sandy loam
SP	sapric material
U	unkown texture
UDOM	undecomposed organics
UWB	unweathered bedrock
VAR	variable
VFS	very fine sand
VFSL	very fine sandy loam
WB	weathered bedrock

Texture modifier (MOD)

BY	bouldery
BYV	very bouldery
BYX	extremely bouldery
CB	cobbly
CBA	angular cobbly
CBV	very cobbly
CBX	extremely cobbly
CN	channery
CNV	very channery
CNX	extremely channery
FL	flaggy
FLV	very flaggy
FLX	extremely flaggy
GR	gravelly
GRC	coarse gravelly
GRF	fine gravelly
GRV	very gravelly
GRX	extremely gravelly
ST	stony
STV	very stony
STX	xtremely stony

Structure grade (GRD)

0	structureless
1	weak
2	moderate
3	strong
4	very strong
5	weak and moderate
6	moderate and strong

Structure size (SZ)

CO	coarse
CV	coarse and very coarse
F	fine
FF	very fine and fine
FM	fine and medium
M	medium
MC	medium and coarse
TK	thick
TN	thin
VC	very coarse
VF	very fine
VK	very thick
VN	very thin

Structure shape (SHP)

ABK	angular blocky
BK	blocky
CDY	cloddy
COL	columnar
CR	crumb
GR	granular
LP	lenticular
MA	massive
PL	platy
PR	prismatic
SBK	subangular blocky
SGR	single grain
WEG	wedge

Dry consistence (DRY)

EH	extremely hard
H	hard
L	loose
S	soft
SH	slightly hard
VH	very hard

Moist consistence (MOIST)

EFI	extremely firm
FI	firm
FR	friable
L	loose
VFI	very firm
VFR	very friable

Other consistence (OTHER)

B	brittle
CO	uncememented
D	deformable
I	indurated
MS	moderately smeary
R	rigid
SC	strongly cemented
SD	semi deformable
SM	smeary
VR	very rigid
VWC	very weakly cemented
WC	weakly cemented
WSM	weakly smeary

Stickiness (ST)

S	sticky
SO	non sticky
SS	slightly sticky
VS	very sticky

Plasticity (PL)

P	plastic
PO	non plastic
SP	slightly plastic
VP	very plastic

Cementing agent (CEM)

H	humus
I	iron
L	lime
S	silica
X	lime and silica

Mottle abundance (AB)

F	few
C	common
M	many

Mottle size (SZ)

1	fine
12	fine and medium
13	medium and coarse
2	medium
3	coarse

Horizon Codes (cont'd)

Mottle distinctness

D	distinct
F	faint
P	prominent

Surface features kind of coat (KND)

A	skeletans over cutans
B	black stains
C	chalcedony on opal
D	clay bridging
G	gibbsite coats
I	iron stains
K	intersecting slickensides
L	lime or carbonate coats
M	manganese or iron-manganese stains
O	organic coats
P	pressure faces
Q	nonintersecting slickensides
S	skeletans (sand or silt)
T	clay films (cutans)
U	coats
X	oxide coats

Abundance of coats (AB)

F	few
C	common
M	many

Continuity of coat (CN)

C	continuous
D	discontinuous
P	patchy

Distinctness of coat (DST)

D	distinct
F	faint
P	prominent

Location of coat (LOC)

B	between sand grains
C	on tops of columns
F	on faces of peds and in pores
H	on horizontal faces of peds
I	in root channels and/or pores
L	on lower surfaces of peds or stones
M	on bottoms of plates
N	on nodules
P	on faces of peds
R	on rock fragments
S	on sand and gravel
T	throughout
U	on upper surfaces of peds or stones
V	on vertical faces of peds
Z	on vert. and hor. faces of peds

Boundary distinctness

A	abrupt
C	clear
D	diffuse
G	gradual

Boundary topography

B	broken
I	irregular
S	smooth
W	wavy

Effervescence class (CL)

0	very slightly effervescent
1	slightly effervescent
2	strongly effervescent
3	violently effervescent

Effervescence agent (AG)

H	HCl, unspecified
I	HCl, 1 normal
O	Hydrogen peroxide, 3 to 4 percent
P	Hydrogen peroxide, unspecified

Effercescence extension (EX)

C	continuous
D	discontinuous

Kind of field measurement (KND)

CL	clay
PB	Bromthymol blue
PC	Cresol red
PG	Bromcresol green
PH	hellige-truog
PL	LaMotte-Morgan
PP	Phenol red
PR	Chlorophenol red
PS	soiltest
PT	Thymol-blue
PY	pH Ydrion
SA	sand
SC	coarse and very coarse sand
SF	fine sand
SI	silt
SM	medium sand
SV	very fine sand
OB	fiber unrubbed
OR	rubbed fiber

Wetness class (WETNESS)

D	dry
M	moist
W	wet

Hydraulic conductivity class

1	Very slow
2	slow
3	Moderately slow
4	Moderate
5	Moderately rapid
6	Rapid
7	Very rapid

Root quantity (QT)

VF	very few
FF	very few to few
F	few
FC	few to common
C	common
CM	common to many
M	many

Root size (SZ)

1	fine 1-2mm
11	very fine and fine
12	fine and medium
13	fine to coarse
2	medium 2-5mm
23	medium and coarse
3	coarse > 5mm
V1	very fine < 1mm

Root location (LOC)

C	in cracks
M	in mat at top of horizon
P	between peds
S	matted around stones
T	throughout

Shape of pore (SHP)

IE	filled with coarse material
IF	void between rock fragments
IR	interstitial
IT	interstitial and tubular
TC	continuous tubular
TD	discontinuous tubular
TE	dendritic tubular
TS	constricted tubular
TU	tubular
VS	vesicular
VT	vesicular and tubular

Quantity of pores (QT)

VF	very few
FF	very few to few
F	few
FC	few to common
C	common
CM	common to many
M	many

Size of pore (SZ)

1	fine .05-2mm
11	very fine and fine
12	fine and medium
13	fine to coarse
2	medium 2-5mm
23	medium and coarse
3	coarse > 5mm
V1	very fine < .05mm

Pore Continuity (CN)

L	Low
M	Moderate
H	High

Horizon Codes (cont'd)

Kind of concentration (KND)

A2	clay bodies
B1	barite crystals
B2	soft masses of barite
C1	calcite crystals
C2	soft masses of lime
C3	lime concretions
C4	lime nodules
D1	mica flakes
D2	soft dark masses
D3	dark concretions
D4	dark nodules
E3	gibbsite concretions
E4	gibbsite nodules
F1	plinthite segregations
F2	soft masses of iron
F3	iron concretions
F4	ironstone nodules
G1	gypsum crystals
G2	masses of gypsum
G3	nests of gypsum
G4	gypsum threads
H1	halite crystals
H2	salt masses
K2	soft masses of carbonate
K3	carbonate concretions
K4	carbonate nodules
K5	carbonate threads
M1	nonmagnetic shot
M2	soft masses of iron-manganese
M3	iron-manganese concretions
M4	magnetic shot
S1	opal crystals
S2	soft masses of silica
S3	silica concretions
S4	durinodes
T2	worm casts
T3	insects casts
T4	worm nodules

Quantity of concentrations (QT)

VF	very few
FF	very few to few
F	few
FC	few to common
C	common
CM	common to many
M	many

Shape of concentration (SHP)

C	cylindrical
D	dendritic
O	rounded
P	plate like
T	threads
Z	irregular

Size of concentration (SZ)

1	fine <2mm
12	fine and medium
2	medium 2-5mm
23	medium and coarse
3	coarse > 5-20mm
34	coarse and very coarse
4	very coarse 20-76mm
45	very coarse and extremely coarse
5	extremely coarse > 76mm

Roundness of rock fragment (RND)

1	angular
2	subangular
3	subrounded
4	rounded
5	well rounded

Size of rock fragment (SZ)

1	pebbles
2	cobbles
3	stones
4	boulders
5	channers
6	flagstones

Kind of rock fragment (KND)

A	sandstone
B	mixed sedimentary
E	ejecta
F	ironstone
H	shale
I	igneous rocks
K	organic fragments
L	limestone
M	metamorphic rocks
O	oxide-protected rock
P	pyroclastic rocks
R	saprolite
S	sedimentary rocks
Y	mixed lithology

Soil Taxonomy Classification Codes

CLASSIFICATION

Classification, Great Group

Alfisols

AAQAL	Albaqualf
AAQDU	Duraqualf
AAQFR	Fragiaqualf
AAQGL	Glossaqualf
AAQKA	Kandiaqualf
AAQNA	Natraqualf
AAQOC	Ochraqualf
AAQPN	Plinthaqualf
AAQUM	Umbraqualf
ABOCR	Cryoboralf
ABOEU	Eutroboralf
ABOFR	Fragiboralf
ABOGL	Glossoboralf
ABONA	Natriboralf
ABOPA	Paleboralf
AUDAG	Agrudalf
AUDFE	Ferrudalf
AUDFR	Fragiudalf
AUDFS	Fraglossudalf
AUDGL	Glossudalf
AUDHA	Hapludalf
AUDKA	Kandiudalf
AUDKH	Kandhapludalf
AUDNA	Natrudalf
AUDPA	Paleudalf
AUDRH	Rhodudalf
AUSDU	Durustalf
AUSHA	Haplustalf
AUSKA	Kandiustalf
AUSKH	Kandhaplustalf
AUSNA	Natrustalf
AUSPA	Paleustalf
AUSPN	Plinthustalf
AUSRH	Rhodustalf
AXEDU	Durixeralf
AXEFR	Fragixeralf
AXEHA	Haploxeralf
AXENA	Natrixeralf
AXEPA	Palexeralf
AXEPN	Plinthoxeralf
AXERH	Rhodoxeralf

Aridisols

DARDU	Durargid
DARHA	Haplargid
DARND	Nadurargid
DARNT	Natrargid
DARPA	Paleargid
DORCL	Calciorthid
DORCM	Camborthid
DORDU	Durorthid
DORGY	Gypsiorthid
DORPA	Paleorthid
DORSA	Salorthid

Entisols

EAQCR	Cryaquent
EAQFL	Fluvaquent
EAQHA	Haplaquent
EAQHY	Hydraquent
EAQPS	Psammaquent
EAQSU	Sulfaquent
EAQTR	Tropaquent
EARAR	Arent
EFLCR	Cryofluvent
EFLTO	Torrifluvent
EFLTR	Tropofluvent
EFLUD	Udifluvent
EFLUS	Ustifluvent
EFLXE	Xerofluvent
EORCR	Cryorthent
EORTO	Torriorthent
EORTR	Troporthent
EORUD	Udorthent
EORUS	Ustorthent
EORXE	Xerorthent
EPSCR	Cryopsamment
EPSQU	Quartzipsamment
EPSTO	Torripsamment
EPSTR	Tropopsamment
EPSUD	Udipsamment
EPSUS	Ustipsamment
EPSXE	Xeropsamment

Histosols

HFIBO	Borofibrist
HFICR	Cryofibrist
HFILU	Luvifibrist
HFIME	Medifibrist
HFISP	Sphagnofibrist
HFITR	Tropofibrist
HFOBO	Borofolist
HFOCR	Cryofolist
HFOTR	Tropofolist
HHEBO	Borohemist
HHECR	Cryohemist
HHELU	Luvihemist
HHEME	Medihemist
HHESI	Sulfihemist
HHESO	Sulfohemist
HHETR	Tropohemist
HSABO	Borosaprist
HSACR	Cryosaprist
HSAME	Medisaprist
HSATR	Troposaprist

Inceptisols

IANCR	Cryandept
IANDU	Durandept
IANDY	Dystrandept
IANEU	Eutrandept
IANHY	Hydrandept
IANPK	Placandept
IANVI	Vitrandept
IAQAN	Andaquept
IAQCR	Cryaquept
IAQFR	Fragiaquept
IAQHL	Halaquept
IAQHP	Haplaquept
IAQHU	Humaquept
IAQPK	Placaquept
IAQPN	Plinthaquept
IAQSU	Sulfaquept
IAQTR	Tropaquept
IOCCR	Cryochrept
IOCDU	Durochrept
IOCDY	Dystrochrept
IOCEU	Eutrochrept
IOCFR	Fragiochrept
IOCUS	Ustochrept
IOCXE	Xerochrept
IPLPL	Plaggept
ITRDY	Dystropept
ITREU	Eutropept
ITRHU	Humitropept
ITRSO	Sombritropept
ITRUS	Ustropept
IUMCR	Cryumbrept
IUMFR	Fragiumbrept
IUMHA	Haplumbrept
IUMXE	Xerumbrept

Mollisols

MALAR	Argialboll
MALNA	Natralboll
MAQAR	Argiaquoll
MAQCA	Calciaquoll
MAQCR	Cryaquoll
MAQDU	Duraquoll
MAQHA	Haplaquoll
MAQNA	Natraquoll
MBOAR	Argiboroll
MBOCA	Calciboroll
MBOCR	Cryoboroll
MBOHA	Haploboroll
MBONA	Natriboroll
MBOPA	Paleboroll
MBOVE	Vermiboroll
MRERE	Rendoll
MUDAR	Argiudoll
MUDHA	Hapludoll
MUDPA	Paleudoll
MUDVE	Vermudoll
MUSAR	Argiustoll
MUSCA	Calciustoll
MUSDU	Durustoll
MUSHA	Haplustoll
MUSNA	Natrustoll
MUSPA	Paleustoll

Soil Taxonomy Classification Codes (cont'd)

Mollisols (cont)

MUSVE	Vermustoll
MXEAR	Argixeroll
MXECA	Calcixeroll
MXEDU	Durixeroll
MXEHA	Haploxeroll
MXENA	Natrixeroll
MXEPA	Palexeroll

Oxisols

OAQAC	Acraquox
OAQEU	Eutraquox
OAQHA	Haplaquox
OAQPN	Plinthaquox
OPRAC	Acroperox
OPREU	Eutroperox
OPRHA	Haploperox
OPRKA	Kandiperox
OPRSO	Sombriperox
OTOAC	Acritorrox
OTOEU	Eutrotorrox
OTOHA	Haplotorrox
OUDAC	Acrudox
OUDEU	Eutrudox
OUDHA	Hapludox
OUDKA	Kandiudox
OUDSO	Sombriudox
OUSAC	Acrustox
OUSEU	Eutrustox
OUSHA	Haplustox
OUDKA	Kandiustox
OUSSO	Sombriustox

Spodosols

SAQCR	Cryaquod
SAQDU	Duraquod
SAQFR	Fragiaquod
SAQHA	Haplaquod
SAQPK	Placaquod
SAQSI	Sideraquod
SAQTR	Tropaquod
SFEFE	Ferrod
SHUCR	Cryohumod
SHUFR	Fragihumod
SHUHA	Haplohumod
SHUPK	Placohumod
SHUTR	Tropohumod
SORCR	Cryorthod
SORFR	Fragiorthod
SORHA	Haplorthod
SORPK	Placorthod
SORTR	Troporthod

Ultisols

UAQAL	Albaquult
UAQFR	Fragiaquult
UAQKA	Kandiaquult
UAQKH	Kandhaplaquult
UAQOC	Ochraquult
UAQPA	Paleaquult
UAQPN	Plinthaquult
UAQUM	Umbraquult
UHUHA	Haplohumult
UHUKA	Kandihumult
UHUKH	Kandhaplohumult
UHUPN	Plinthohumult
UHUSO	Sombrihumult
UUDFR	Fragiudult
UUDHA	Hapludult
UUDKA	Kandiudult
UUDKH	Kandhapludult
UUDPA	Paleudult
UUDPN	Plinthudult
UUDRH	Rhodudult
UUSHA	Haplustult
UUSKA	Kandiustult
UUSKH	Kandhaplustult
UUSPA	Paleustult
UUSPN	Plinthustult
UUSRH	Rhodustult
UXEHA	Haploxerult
UXEPA	Palexerult

Vertisols

VTOTO	Torrert
VUDCH	Chromudert
VUDPE	Pelludert
VUSCH	Chromustert
VUSPE	Pellustert
VXECH	Chromxerert
VXEPE	Pelloxerert

Classification, Subgroup

AA	Typic

AB	Abruptic
AB04	Abruptic aridic
AB08	Abruptic cryic
AB10	Abruptic haplic
AB14	Abruptic udic
AB16	Abruptic xerollic

AC	Acric
AC05	Acric Plinthic

AE	Aeric
AE03	Aeric arenic
AE05	Aeric grossarenic
AE06	Aeric humic
AE08	Aeric mollic
AE09	Aeric tropic
AE10	Aeric umbric

AL	Albaquic
AL02	Albaquultic
AL04	Albic
AL08	Albic glossic
AL10	Alfic
AL12	Alfic arenic
AL13	Alfic andeptic
AL16	Alfic lithic

AN	Andic
AN01	Andeptic
AN03	Andaquic
AN06	Andic dystric
AN08	Andic epiaquic
AN11	Andeptic glossoboric
AN20	Andic udic
AN22	Andic ustic
AN24	Andaqueptic
AN25	Anionic
AN30	Anthropic

AQ	Aqualfic
AQ02	Aquentic
AQ04	Aqueptic
AQ06	Aquic
AQ07	Aquic anionic
AQ08	Aquic arenic
AQ14	Aquic duric
AQ16	Aquic duriorthidic
AQ18	Aquic dystric
AQ24	Aquic haplic
AQ26	Aquic lithic
AQ28	Aquic petroferric
AQ34	Aquollic
AQ36	Aquultic

AR	Arenic
AR02	Arenic aridic
AR04	Arenic plinthaquic
AR06	Arenic plinthic
AR08	Arenic rhodic
AR10	Arenic ultic
AR14	Arenic umbric
AR16	Arenic ustalfic
AR18	Arenic ustollic
AR22	Argiaquic
AR24	Argiaquic xeric
AR26	Argic
AR28	Argic lithic
AR30	Argic pachic
AR32	Argic vertic
AR34	Aridic
AR36	Aridic calcic
AR42	Aridic duric
AR52	Aridic petrocalcic

BO	Boralfic
BO02	Boralfic lithic
BO04	Boralfic udic
BO06	Borollic
BO08	Borollic glossic
BO10	Borollic lithic
BO12	Borollic vertic

Soil Taxonomy Classification Codes (cont'd)

Classification, Subgroup (cont)

CA	Calcic
CA04	Calcic pachic
CA06	Calciorthidic
CA10	Calcixerollic
CA20	Cambic
CH	Chromic
CR	Cryic
CR10	Cryic lithic
CR14	Cyric pachic
CU	Cumulic
CU02	Cumulic udic
CU04	Cumulic ultic
DU	Durargidic
DU02	Duric
DU08	Durixerollic
DU10	Durixerollic lithic
DU12	Durorthidic
DU14	Durorthidic xeric
DY02	Dystric
DY03	Dystric entic
DY04	Dystric fluventic
DY06	Dystric lithic
EN	Entic
EN02	Entic lithic
EN06	Entic ultic
EP	Epiaquic
EU	Eutric
EU02	Eutrochreptic
EU04	Eutropeptic
FE	Ferrudalfic
FI	Fibric
FI02	Fibric terric
FL02	Fluvaquentic
FL06	Fluventic
FL12	Fluventic umbric
FR10	Fragiaquic
FR18	Fragic
GL02	Glossaquic
GL04	Glossic
GL10	Glossic udic
GL12	Glossic ustollic
GL16	Glossoboric
GR	Grossarenic
GR01	Grossarenic entic
GR04	Grossarenic plinthic
GY	Gypsic
HA	Haplaquodic
HA02	Haplic
HA07	Haploxerollic
HA09	Hapludic
HA12	Hapludollic
HA16	Haplustollic
HE	Hemic
HE02	Hemic terric
HI	Histic
HI02	Histic lithic
HI06	Histic pergelic
HU	Humic
HU02	Humic lithic
HU05	Humic pergelic
HU10	Humaqueptic
HU15	Humic rhodic
HU20	Humic xanthic
HY	Hydric
HY02	Hydric lithic
IN	Inceptic
KA	Kandic
KA02	Kandiudalfic
KA04	Kandiustalfic
KH	Kandhaplic
LE	Leptic
LI	Limnic
LI02	Lithic
LI04	Lithic mollic
LI05	Lithic pergelic
LI03	Lithic petrocalci
LI06	Lithic ruptic-alfic
LI07	Lithic ruptic-argic
LI08	Lithic ruptic-entic-xerollic
LI09	Lithic ruptic-entic
LI11	Lithic ruptic-xerorthentic
LI12	Lithic ultic
LI13	Lithic ruptic-ultic
LI14	Lithic umbric
LI15	Lithic ruptic-xerochreptic
LI16	Lithic ustic
LI18	Lithic ustollic
LI22	Lithic xeric
LI24	Lithic xerollic
MO	Mollic
NA06	Natric
OC	Ochreptic
OR	Orthidic
OR01	Orthic
OR02	Orthoxic
OX	Oxic
PA	Pachic
PA02	Pachic udic
PA04	Pachic ultic
PA08	Paleustollic
PA10	Palexerollic
PE	Pergelic
PE01	Pergelic ruptic-histic
PE02	Pergelic sideric
PE04	Petrocalcic
PE06	Petrocalcic ustalfic
PE08	Petrocalcic ustollic
PE14	Petrocalcic xerollic
PE16	Petroferric
PE20	Petrogypsic
PK	Placic
PK10	Plaggeptic
PK12	Plaggic
PL	Plinthaquic
PL04	Plinthic
PL06	Plinthudic
PS	Psammaquentic
PS02	Psammentic
QU	Quartzipsammentic
RE	Rendollic
RH	Rhodic
RU02	Ruptic-alfic
RU09	Ruptic-lithic
RU11	Ruptic-lithic-entic
RU15	Ruptic-lithic-xerochreptic
RU17	Ruptic-ultic
RU19	Ruptic-vertic
SA	Salorthidic
SA02	Sapric
SA04	Sapric terric
SI	Sideric
SO	Sombric
SP	Sphagnic
SP02	Sphagnic terric
SP04	Spodic
SU	Suflic
TE	Terric
TH04	Thapto-histic
TH06	Thapto-histic tropic
TO	Torrertic
TO02	Torrifluventic
TO04	Torriorthentic
TO06	Torripsammentic
TO10	Torroxic

Soil Taxonomy Classification Codes (cont'd)

Classification, Subgroup (cont)

TR	Tropaquodic
TR04	Tropic
UD	Udertic
UD01	Udalfic
UD02	Udic
UD03	Udollic
UD05	Udorthentic
UL	Ultic
UM	Umbreptic
UM02	Umbric
US	Ustalfic
US02	Ustertic
US04	Ustic
US06	Ustochreptic
US08	Ustollic
US12	Ustoxic
VE	Vermic
VE02	Vertic
XA	Xanthic
XE	Xeralfic
XE02	Xerertic
XE04	Xeric
XE08	Xerollic

Classification, Particle Size Class

003	cindery
004	cindery over sandy or sandy-skeletal
005	ashy
006	cindery over loamy
007	ashy over cindery
008	ashy over loamy
009	ashy-skeletal
010	medial
011	medial-skeletal
012	medial over cindery
013	ashy over loamy-skeletal
014	medial over clayey
015	cindery over medial-skeletal
016	medial over fragmental
017	cindery over medial
018	medial over loamy
019	ashy over medial
020	medial over loamy-skeletal
022	medial over sandy or sandy-skeletal
024	medial over thixotropic
026	thixotropic
027	thixotropic-skeletal
028	thixotropic over fragmental
030	thixotropic over sandy or sandy-skeletal
032	thixotropic over loamy-skeletal
034	thixotropic over loamy
036	fragmental
044	sandy-skeletal
046	sandy-skeletal over loamy
050	loamy-skeletal
051	loamy-skeletal over fragmental
052	loamy-skeletal over sandy
054	loamy-skeletal over clayey
055	loamy-skeletal or clayey-skeletal
056	clayey-skeletal
058	clayey-skeletal over sandy
062	sandy
063	sandy or sandy-skeletal
064	sandy over loamy
066	sandy over clayey
068	loamy
072	loamy over sandy or sandy-skeletal
080	coarse-loamy
082	coarse-loamy over fragmental
084	coarse-loamy over sandy or sandy-skeletal
086	coarse-loamy over clayey
088	coarse-silty
092	coarse-silty over sandy or sandy-skeletal
094	coarse-silty over clayey
096	fine-loamy
097	fine-loamy over cindery
098	fine-loamy over fragmental
100	fine-loamy over sandy or sandy-skeletal
102	fine-loamy over clayey
106	fine-silty
108	fine-silty over fragmental
110	fine-silty over sandy or sandy-skeletal
112	fine-silty over clayey
114	clayey
116	clayey over fragmental
118	clayey over sandy or sandy-skeletal
120	clayey over loamy-skeletal
122	clayey over fine-silty
124	clayey over loamy
126	fine
134	very fine

Classification, Mineralogy Class

03	Allitic
05	carbonatic
08	coprogenous
09	chloritic
10	diatomaceous
12	ferrihumic
14	ferritic
16	ferruginous
18	gibbsitic
20	glauconitic
22	gypsic
24	halloysitic
26	illitic
27	illitic (calcareous)
28	kaolinitic
30	marly
32	micaceous
34	mixed
35	mixed (calcareous)
37	montmorillonitic
38	montmorillonitic (calcareous)
40	oxidic
44	serpentinitic
46	siliceous
47	siliceous (calcareous)
48	sesquic
50	vermiculitic

Classification, Reaction Class

04	acid
06	allic
08	dysic
10	euic
12	nonacid
14	noncalcareous

Classification, Temperature Regime

04	frigid
06	hyperthermic
08	isofrigid
10	isohyperthermic
12	isomesic
14	isothermic
16	mesic
18	thermic

Classification, Other Class

04	coated
05	cracked
06	level
08	micro
12	ortstein
14	shallow
15	shallow & uncoated
16	sloping
17	shallow & coated
20	uncoated

APPENDIX B:

DIRECT/DELAYED RESPONSE PROJECT:
QUALITY ASSURANCE PLAN FOR SOIL SAMPLING IN THE MID-APPALACHIAN REGION OF THE UNITED STATES

by

Jeffrey S. Kern
NSI Technology Services Corporation
USEPA Environmental Research Laboratory
200 SW 35th Street
Corvallis, Oregon 97333

Jeffrey J. Lee
US Environmental Protection Agency
USEPA Environmental Research Laboratory
200 SW 35th Street
Corvallis, Oregon 97333

US Environmental Protection Agency
USEPA Environmental Research Laboratory
200 SW 35th Street
Corvallis, Oregon 97333

EXECUTIVE SUMMARY

The Direct/Delayed Response Project (DDRP) of the National Acid Precipitation Assessment Program is a United States Environmental Protection Agency (USEPA) program to reduce the uncertainties in current understanding of the effects of acidic deposition on surface water chemistry. The response of watersheds to acidic deposition will be assessed for selected regions of concern using data from DDRP soil surveys, USEPA surface water surveys, and acidic deposition data. The three phases of DDRP soil surveys are watershed mapping, soil sampling, and sample analysis. DDRP soil surveys have been completed in the Northeast Region and Southern Blue Ridge Region of the United States.

This Quality Assurance Project Plan presents the policies, organization, functional activities, and specific quality assurance/quality control activities designed to achieve the data quality goals of the DDRP Mid-Appalachian Soil Survey.

The achievement of these data quality goals are assured by the following:

- Field operations will be conducted using detailed protocols based on previous DDRP soil surveys;
- Personnel involved in the sampling activities will be trained by persons knowledgeable in the sampling protocols;
- Crews will be visited by three different auditors to ensure that crews are conducting their activities according to protocols and are providing the necessary documentation;
- Sample and location codes on field forms and sample labels will be carefully checked at the time of receipt at a soil preparation laboratory;
- Two of the auditors will prepare duplicate site and profile descriptions during their audits to evaluate the accuracy and precision of the descriptions. Site and soil profile descriptions will be verified for invalid codes and computer entry errors by the preparation laboratory. The quality of the descriptions will be evaluated by regional experts in soil science following the sampling activities;
- Three types of performance evaluation samples will be analyzed by the preparation laboratory during sampling and by analytical laboratories after sampling is complete. These data will be evaluated using the data quality objectives; and
- Problems identified in any of the quality assurance activities will be addressed by corrective actions.

ACKNOWLEDGEMENTS

The quality assurance (QA) design for the Direct/Delayed Response Project (DDRP) Mid-Appalachian Soil Survey is based, in a large part, on the previous DDRP surveys. Personnel involved are identified in the first DDRP Soil Sampling, Preparation and Analysis QA Plan (Bartz et al., 1987) and the Field Operations and QA Reports for the Northeast Region (Coffey et al, 1987a) and the Southern Blue Ridge Province (Coffey et al., 1987b). Craig Palmer, of the Environmental Research Center, Las Vegas, participated in the development of much of the present QA design. A special thanks goes to Carol Roberts of NSI-Technnology Services Corporation, Corvallis, Oregon, for her patient typing of drafts of this QA Plan.

TABLE OF CONTENTS

EXECUTIVE SUMMARY 128

ACKNOWLEDGEMENTS 129

1 SIGNATURE PAGE 132

2 LIST OF TABLES 133

3 LIST OF FIGURES 133

4 INTRODUCTION 134
  QUALITY ASSURANCE (QA)/QUALITY CONTROL (QC) 134
  QA REQUIREMENTS 134
  QA ELEMENTS 134

5 PROJECT DESCRIPTION 136
  DATA COLLECTION APPROACH 136
    Watershed Mapping 136
    Soil Sampling Classes 136
    Sampling Site Selection 136

6 PROJECT ORGANIZATION AND RESPONSIBILITY 137
  FIELD CREWS 137
  SAMPLING TASK LEADER 139
  QA/QC PERSONNEL 139
    USDA Soil Conservation Service (SCS), State Soils Staffs 139
    Regional Coordinator/Correlator (RCC) 139
    QA/QC Auditors 140

7 QA OBJECTIVES FOR MEASUREMENT 141
  QA OBJECTIVES 141
    Accuracy 141
    Precision 143
    Completeness 143
    Representativeness 144
    Comparability 144
  DATA QUALITY OBJECTIVES 145
    Accuracy 145
    Precision 146
    Representativeness 146
    Completeness 146

8 SAMPLING PROCEDURES 150

9 SAMPLE CUSTODY 151

10 CALIBRATION PROCEDURES AND FREQUENCY 152

11 ANALYTICAL PROCEDURES 153

12 DATA REDUCTION, VALIDATION AND REPORTING 154

13 INTERNAL QUALITY CONTROL CHECKS AND FREQUENCY 155

14 PERFORMANCE AND SYSTEM AUDITS 156
PERFORMANCE AUDITS 156
SYSTEMS AUDITS 156
SCS State Soils Staffs Audits 156
RCC Audits 157
QA Audits 157

15 PREVENTATIVE MAINTENANCE 159

16 SPECIFIC ROUTINE PROCEDURES TO ASSESS DATA QUALITY 160
EVALUATION OF DESCRIPTION DATA 160
EVALUATION OF PERFORMANCE EVALUATION SAMPLE DATA 160

17 CORRECTIVE ACTIONS 161

18 QUALITY ASSURANCE REPORTS TO MANAGEMENT 162

19 REFERENCES 163

20 AUDIT FORM FOR QA PERSONNEL 164

1 SIGNATURE PAGE

2 LIST OF TABLES

Table 1-1 Elements of a QA Plan 135
Table 4-1 MQOs for Mineral Horizons for the DDRP Mid-Appalachian Soil Survey 147
Table 4-2 MQOs for Organic Horizons for the DDRP Mid-Appalachian Soil Survey 148

3 LIST OF FIGURES

Figure 3-1 QA Organizational Chart of the Sampling Activities 138

4 INTRODUCTION

QUALITY ASSURANCE (QA)/QUALITY CONTROL (QC)

The QA Program of the US Environmental Protection Agency (USEPA) is designed to assure that the collection of data by monitoring and measurement projects are scientifically sound, legally defensible, and of known quality. Every monitoring and measurement project must have a written and approved QA Project Plan (QAPP) to document the policies, organization, functional activities and specific QA and quality control (QC) activities that are designed to achieve the data quality goals of the project. This document presents the QA program for the soil sampling activities of the USEPA's Direct/Delayed Response Project (DDRP) in the Mid-Appalachian Region of the United States. The soil sampling activities are part of the DDRP watershed surveys, which include watershed mapping and soil characterization. The protocols for these sampling activity are presented in Appendix A.

QA REQUIREMENTS

It is the policy of the USEPA that each office or laboratory generating data must implement procedures to ensure that precision, accuracy, completeness, comparability, and representativeness of data are known and documented (Quality Assurance Management Staff (QAMS), 1980). A written QAPP is required to specify the quality that the data must satisfy to be acceptable for the intended use.

QA ELEMENTS

Sixteen elements (Table 1-1) must be included for consideration in a QAPP (QAMS, 1980). The first two elements are a title page with provision for appropriate signatures and a table of contents. The other fourteen elements are sections 5 through 18 listed in the table of contents.

Table 1-1 Elements of a QA Plan

	Element
1.	Title page with provision for approval signatures
2.	Table of contents
3.	Project description
4.	Project organization and responsibility
5.	QA objectives for measurement data in terms of accuracy, precision, completeness, representativeness and comparability
6.	Sampling procedures
7.	Sample Custody
8.	Calibration procedures and frequency
9.	Analytical procedures
10.	Data reduction, validation and reporting
11.	Internal quality control checks and frequency
12.	Performance and systems audits
13.	Preventative maintenance
14.	Specific routine procedures used to assess data precision, accuracy, and completeness
15.	Corrective action
16.	Quality assurance reports to management

5 PROJECT DESCRIPTION

The DDRP is an integral component of the acidic deposition research program of the USEPA. It is conducted under the federally mandated National Acid Precipitation Program (NAPAP). DDRP is managed by the Environmental Research Laboratory, Corvallis (ERL-C). Logistical and QA/QC support to the DDRP are provided by the USEPA Environmental Systems Monitoring Laboratory in Las Vegas, Nevada, (EMSL-LV). ERL-C has responsibility for QA/QC for soil sampling and mapping. A description of the DDRP is presented in section 1 of the first part of this report.

DATA COLLECTION APPROACH

Watershed Mapping

Selected watersheds were mapped to determine the spatial variability of soils, depth to bedrock, landuse, forest cover type, and drainage and bedrock geology following protocols outlined by Kern et al. (1990).

Soil Sampling Classes

Soils, identified in the mapping phase, are combined into sampling classes that are thought, or known, to be similar in properties that are important in determining the responses of surface waters (lakes, streams) to acidic deposition. This is done at a workshop by soil scientists familiar with soils in each region, in conjunction with modelers and statisticians who will use the soil data. Each of the sampling classes is sampled across a number of watersheds in which it occurs. Note that in this approach, a given soil sample does not represent the specific watershed from which it came; instead, it contributes to a set of samples which, collectively, represent a specific sampling class on all DDRP watersheds having soils in that sampling class. A flowchart of the soil sampling classes is given in Figure 1-3 of the first section of this report.

Sampling Site Selection

The site selection procedures for the sampling is discussed in detail in the protocols which are included as Appendix A.

6 PROJECT ORGANIZATION AND RESPONSIBILITY

An organizational chart of the QA responsibilities for DDRP Mid-Appalachian Soil Survey sampling activities is presented in Figure 3-1.

FIELD CREWS

Each field crew consists of one crew leader who is a soil scientist experienced in National Cooperative Soil Survey (NCSS) procedures and two to three other crew members who may also be soil scientists.

The lead soil scientist in each crew supervises all field operations and decisions. This person is also responsible for selecting each sampling site and for documenting all field data. The field crew leader has the responsibility to:

- obtain soil samples from the sampling classes selected for characterization;
- make decisions concerning soil description and sampling including horizon delineation, horizon thickness, and material excluded from the samples;
- ensure that site and pedon descriptions, logbooks and labels are legible and accurate and that photographs are taken properly;
- ensure proper use and maintenance of field equipment, including cleaning between each sample;
- minimize contamination of samples particularly from soil or solution found above or below the horizon being sampled;
- maintain sample integrity (primarily by storage at 4°C) until shipping to the preparation laboratory;
- track sample shipment to assure that the correct number of samples have been shipped in the manner specified in these protocols;
- report to the Sampling Task Leader at ERL-C any problems or difficulties encountered while sampling or transporting soil samples at the earliest opportunity; and
- return all unused USEPA-issued field equipment and supplies to the State Soils Staffs for shipment to the USEPA.

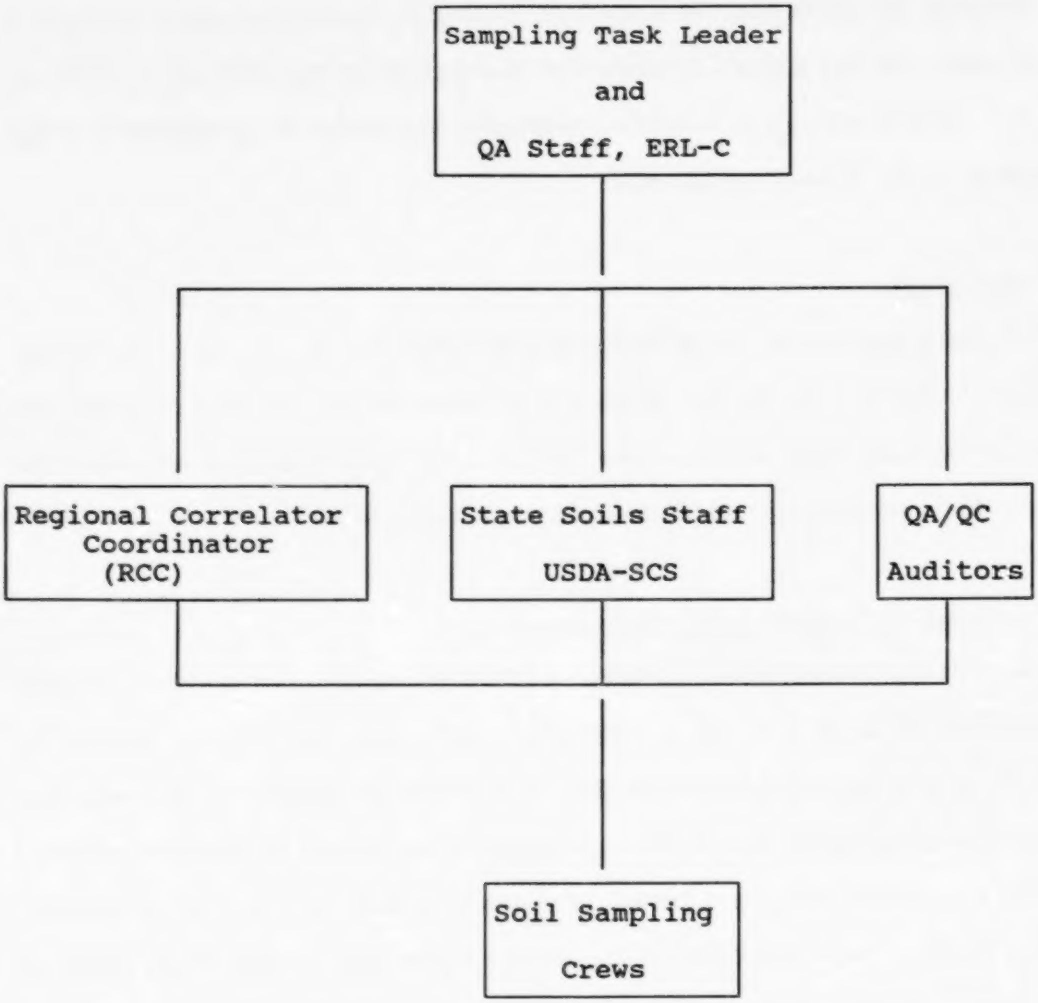

Sampling Task Leader
and
QA Staff, ERL-C
Regional Correlator
Coordinator
(RCC)
State Soils Staff
USDA-SCS
QA/QC
Auditors
Soil Sampling
Crews

Figure 3-1 QA Organizational Chart of the Sampling Activities

SAMPLING TASK LEADER

The Sampling Task Leader from ERL-C has overall responsibility for the soil sampling activities and the QA program. The Task Leader coordinates work on this project by the USEPA and the SCS. All of the audit personnel submit audit reports to the Sampling Task Leader who is responsible to see that corrective actions, if necessary, are taken.

QA/QC PERSONNEL

The following personnel have responsibilities for auditing field crews to verify that all field activities are conducted using the protocols. Evaluations are discussed with field crews immediately following audits so that crews are aware of any potential problems. The QA/QC support personnel have the authority to resolve problems that may affect sample quality during audits.

USDA Soil Conservation Service (SCS), State Soils Staffs

A representative of each of the SCS State Soils Staffs will conduct a field methods evaluation for a minimum of one sampling site per field crew. Independent pedon descriptions are prepared by the State Soils Staff to assess soil variability at each site, to evaluate the differences in site descriptions among soil scientists and to promote consistent application of soil concepts for describing pedons.

The State Soil Staffs will be responsible for assignment and supervision of crews, for reviewing all pedon descriptions forms (232-Forms) at the end of sampling, and for return to the USEPA of supplies and equipment issued by the USEPA.

Regional Coordinator/Correlator (RCC)

The RCC is a qualified soil scientist with extensive experience in soil profile description, mapping and sampling. The RCC will monitor one site per field crew for adherence to NCSS standards, procedures, and for modifications to the sampling protocols presented in this document. The RCC will prepare an independent report on soil descriptions using the same guidelines discussed above for the State Soils Staffs. The RCC will follow the same guidelines for audits as the SCS State Soils Staffs.

The RCC will monitor at least one site in each state in conjunction with the State Soil Staff representative; the remaining sites may be monitored independently.

QA/QC Auditors

The DDRP QA Coordinator from ERL-C will lead QA/QC audits of field crews and a representative from EMSL-LV may participate in these audits. QA/QC audits will be conducted at least once for each sampling crew near the beginning of sampling and again near the completion, if possible. The major purpose of these audits is to assess the degree of adherence to protocols.

7 QA OBJECTIVES FOR MEASUREMENT

The intent of the USEPA QA program is to ensure that data collected are scientifically sound, legally defensible and of known quality (QAMS, 1980). Training, uniform use of protocols, field audits by three different auditors, performance evaluation samples, site and profile description verification and sample tracking by the prep lab attempt to assure that samples are obtained that represent the pedons chosen for sampling, that samples are not contaminated, that samples are handled correctly, and that samples are accompanied by detailed documentation.

QA OBJECTIVES

Quality assurance objectives are defined in terms of the following characteristics (QAMS, 1980):

- Accuracy
- Precision
- Representativeness
- Completeness
- Comparability

These characteristics are defined and discussed below.

Accuracy

Accuracy is the degree of agreement of a measurement (or an average of measurements) with an accepted reference or true value.

The concept of accuracy, as it applies to soil sample collection, encompasses four objectives:

- that the site and soil descriptions accurately document field conditions and identify the appropriate horizons for sampling;
- that samples be collected in a way that accurately reflects the pedon chosen for sampling;
- that the accuracy not be impacted by the way the crew sieved and bagged the sample; and,
- that the accuracy not be affected by transporting the sample to the preparation lab.

The accuracy of site and soil descriptions will be assessed by field reviews and independent (duplicate) descriptions by the RCC and the SCS State Soils Staffs. The evaluators will discuss any questions or concerns with the descriptions with the crew to promote uniform application of concepts and consistency among the crews. Verification at the prep lab will ensure the accuracy of the descriptions by checking for valid codes and labeling. Discrepancies identified in the verification process will be resolved directly with the crew leaders. The SCS State Soils Staffs will review the descriptions at the completion of sampling to evaluate if they are logical, with respect to similar descriptions of soils in that region, and to check the classification.

The degree that the samples accurately reflect the pedon sampled will be evaluated by observing the way crews obtain samples from soil pits during audits by the RCC, SCS State Soils Staffs, and the QA auditors. Samples must be obtained from representative cross sections of horizons that are identified in profile descriptions. The effect on accuracy of sieving, bagging, and transporting samples is evaluated during audits by the RCC, SCS State Soils Staff and QA auditors.

The effect on accuracy of sampling, sieving, bagging, transporting and shipping samples will be evaluated by examining if data values for one type of performance evaluation samples, low level field audit samples, fall within calculated confidence intervals. Another type of performance evaluation samples, field audit sample pairs, will be evaluated to see if the relative standard deviation (RSD) of the data values are less than those of the quality objectives.

Analysis of the performance evaluation samples will provide some indication whether sample contamination may have occurred; it does not, in itself, conclusively indicate where the contamination is occurring. Examination of the data generated from the sample obtained immediately prior to handling the performance evaluation sample may provide some indication if there is cross contamination from sampling, sieving and bagging. Examination of the crew logbook Soil Sampling Notes sections will provide information to evaluate sample transport and storage that will be used in conjunction with the performance evaluation sample data.

A visual inspection of samples received at the prep lab will provide an evaluation of evidence that sample integrity may have been impacted during sample shipment. Analysis of the performance evaluation samples will provide some measure of potential sample contamination in conjunction with the visual inspection.

Precision

Precision is a measure of mutual agreement among individual measurements of the same property. In analytical laboratory work, precision is the agreement of measurements on a sample made by the same lab and/or different labs. In the context of soil sampling, one measure of precision is obtained by assessing the ability of field crews to collect from a horizon more than one sample that have similar properties (field duplicate samples). These field duplicate samples may also reflect soil spatial variability. Field duplicate sample data will be compared to routine sample data from the same horizon to evaluate if the variability is within the limits set by the quality objectives.

For precision between crews, it is important that all the crews use the same sampling protocols and methods. The sampling training workshop, conducted before sampling begins, will promote consistent adherence to protocols for all crews. Field visits by the RCC will promote precision between crews in uniform sampling field methods because the RCC will visit crews from all states in the region. The QA auditors visit all the crews, which will promote precision between all the crews.

The independent descriptions by the RCC and State Soil Staffs will promote precision of descriptions by providing crews with feedback concerning proper use and consistency of terminology.

Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions.

Completeness for soil sampling is the number of pedons sampled out of the total number of preselected pedons. Completeness, for the sampling of these pedons, is that samples are collected from all horizons specified by the protocols (horizons > 3 cm in thickness to a depth of 2 meters or bedrock). Routine samples from each of these horizons are required that yield a minimum of 3.5 L of air dried material that passes a 2 mm sieve for mineral soil or 7 L of organic soil. From every third pedon a field duplicate sample will be collected from 1 horizon and 3 field audit samples are sieved and bagged. Crews will attempt to obtain samples for determination of bulk density for each mineral soil horizon.

Representativeness

Representativeness expresses the degree to which data accurately and precisely represent characteristics of a population. Sampling sites will be selected randomly in map units where the targeted combination of soil and vegetation is found. The concept that samples must accurately reflect the soil material exposed in a given pedon overlaps with the concept of representativeness. That is, the sample itself should be an accurate representation of the pedon.

An important concept for representativeness in soil sampling is that the sites selected conform to the preselected soil and vegetation classes, and that samples have been obtained that represent the cross-section of the pedon exposed in that pit.

Comparability

Comparability is the confidence with which one data set can be compared with another. This is assured by the use of the same or similar sampling protocols in all surveys.

The DDRP soil sampling protocols have been revised (see Appendix A) from the previous Northeastern and Southern Blue Ridge protocols. Revisions were necessary because of the addition of field audit sample handling, fewer field duplicates and two new types of bulk density samples that were added because of a concern about completeness. The sampling of paired pedons, two similar sites in close proximity, has been discontinued in this survey because they did not provide information concerning sampling error, and more useful information on soil spatial variability could be obtained by substituting additional routine pedons for the paired pedons.

Field personnel for all the DDRP soil sampling activities are similar to those in previous DDRP soil surveys. Site selection and procedures have remained unchanged, site and soil profile description procedures have remained similar despite revisions to the field form (232-Form). Methods for collection of routine, field duplicate and bulk density clods are unchanged throughout the DDRP soil surveys.

The lower depth for sampling if bedrock was not encountered was 1.5 m for the Northeast sampling, 1.5 to 2.0 m for the Southern Blue Ridge and 2.0 m for this survey. In both prior surveys samples were kept cool (4°C) and were transported by car or truck to regional preparation labs. In this survey samples are kept cool and are shipped by overnight carrier to a preparation lab in Las Vegas.

DATA QUALITY OBJECTIVES

Accuracy

Data quality objectives (DQOs) are evaluated for a project to ensure that the data generated are of sufficient quality to be useful for the project. Data of excess quality may not provide any additional information and might hinder a project because of extra costs. The DQOs must be established based on the needs of the project, cost-effective considerations and the capability of the measurement process (Taylor, 1987). The data will be of sufficient quality for the DDRP if they meet the criteria in this QA plan. Specific numerical criteria of quality will be referred to as measurement quality objectives (MQOs).

The quality objectives for the site and soil profile descriptions are that they correctly portray the field conditions using standard SCS terminology (Soil Survey Staff, 1983) and additional description when necessary. The assessment of the quality of descriptions will be made using the expert judgments of the SCS State Soils Staff and the RCC.

Samples must accurately reflect the pedon from which they were sampled. There are no standards or reference values with which to assess this. Close agreement between the data for routine samples and field duplicates for a given horizon will suggest, but do not prove, that the samples are accurate.

To ensure sample accuracy, sample integrity will be controlled by eliminating or limiting contamination or alteration of samples when they are sieved, bagged and transported. Any such contamination must remain at a minimum or the characteristics of the sample may be compromised. Field audit samples (3 known audit samples that will be carried into the field and then sieved and rebagged along with routine samples every third pedon) should give an indication if contamination is occurring.

The MQOs for field audit sample results are that the standard deviation for samples at the lower concentration range or the RSD be less than or equal to 2 times the MQO given in Table 4-1 for mineral samples and 4-2 for organic samples.

QA staff at EMSL-LV will develop accuracy acceptance guidelines for the field audit low samples based on data obtained about these samples during previous DDRP surveys.

Organic matter loss-on-ignition (LOI) and pH determinations made at the preparation lab will provide data regarding sample handling during sampling for evaluating, if contamination to field audits is significant and will generate feedback to sampling crews. Data from the analytical labs will not be available until after sampling is completed.

Precision

A comparison of data from routine samples and their corresponding field duplicates will provide an indication of whether field crews can collect more than one sample for a horizon that accurately reflect the true properties of that horizon. The MQOs for field duplicates are three times the MQOs in Tables 4.1 and 4.2.

Representativeness

Representativeness expresses the degree to which data accurately and precisely represent characteristics of a population. Sampling sites are selected randomly in map units where the targeted combination of soil and vegetation is found.

The objective is that field crews will sample only pedons which have the preselected sampling class and the preselected vegetation. The crews then must obtain samples from the pedon exposed in the pit so that the material collected is a characteristic or typical sample.

Completeness

The completeness objective for the collection of routine samples, field duplicates, and the handling of field audits is 100 percent.

Due to physical difficulties and the methods employed, completeness of 85 percent for bulk density samples is anticipated. Field crews are instructed to obtain clods wherever possible and, if clods are not obtainable, to use the volume-replacement method. If the volume-replacement method will not work for a horizon, the volume-filling method should be used for sandy loose material, horizons with extremely abundant roots, horizons with a large rock fragment content, and thin horizons with

Table 4-1 MQOs for Mineral Horizons for the DDRP Mid-Appalachian Soil Survey

Parameter	Units	Lower Limit (reporting units)	Upper Limit %	Crossover * Lower/Upper
pH (H_2O)	-log(H^+)	0.10	–	–
pH (.01M $CaCl_2$)	-log(H^+)	0.10	–	–
pH (.002M $CaCl_2$)	-log(H^+)	0.10	–	–
Sand	wt. %	3.0	–	–
Silt	wt. %	3.0	–	–
Clay	wt. %	2.0	–	–
Ca (1N NH_4Cl)	meq/100g	0.02	10	0.2
Mg (1N NH_4Cl)	"	0.02	10	0.2
K (1N NH_4Cl)	"	0.02	10	0.2
Na (1N NH_4Cl)	"	0.02	10	0.2
Al (1N NH_4Cl)	"	0.20	15	1.3
Ca (1N NH_4OAc)	meq/100g	0.02	10	0.2
Mg (1N NH_4OAc)	"	0.02	10	0.2
K (1N NH_4OAc)	"	0.02	10	0.2
Na (1N NH_4OAc)	"	0.02	10	0.2
Ca (0.002M $CaCl_2$)	meq/100g	0.05	5	1.0
Mg (0.002M $CaCl_2$)	"	0.005	10	0.05
K (0.002M $CaCl_2$)	"	0.005	10	0.05
Na (0.002M $CaCl_2$)	"	0.005	10	0.05
Fe (0.002M $CaCl_2$)	"	0.01	15	0.07
Al (0.002M $CaCl_2$)	"	0.05	15	0.33
CEC (1N NH_4OAc)	"	0.25	10	2.5
CEC (0.01M $CaCl_2$)	"	0.25	10	2.5
Acidity ($BaCl_2$-TEA)	"	1.0	15	6.7
Fe (0.1M pyrophosphate)	wt. %	0.03	10	0.3
Al (0.1M pyrophosphate)	"	0.03	10	0.3
Extractable in ammonium oxalate-oxalic acid				
Fe	wt%	0.03	10	0.3
Al	"	0.03	10	0.3
Si		0.03	10	0.3
Extractable in citrate dithionite				
Fe	wt%	0.03	10	0.3
Al	"	0.03	10	0.3
SO_4 isotherm pts	mg S/L	0.1	5	0.5
SO_4 (H_2O)	mg S/Kg	1.5	10	15
SO_4 (PO_4)	"	1.5	10	15
Total S	wt%	0.002	10	0.02
Total N	"	0.015	10	0.15
Total C	"	0.05	10	0.5

(* lower limit MQOs apply below these values of the parameters.)
MQOs for preparation duplicates are 1.5 times and field duplicates are 3 times the values in this table.

Table 4-2 MQOs for Organic Horizons for the DDRP Mid-Appalachian Soil Survey

Parameter	Units	Lower Limit (reporting units)	Upper Limit %	Crossover * Lower/Upper
pH (H_2O)	$-\log(H^+)$	0.10	--	--
pH (.01M $CaCl_2$)	$-\log(H^+)$	0.10	--	--
pH (.002M $CaCl_2$)	$-\log(H^+)$	0.10	--	--
Particle size analysis not done on organic				
Ca (1N NH_4Cl)	meq/100g	0.1	10	1.0
Mg (1N NH_4Cl)	•	0.1	10	1.0
K (1N NH_4Cl)	•	0.1	10	1.0
Na (1N NH_4Cl)	•	0.1	10	1.0
Al (1N NH_4Cl)	•	0.5	15	3.3
Ca (1N NH_4OAc)	meq/100g	0.1	10	1.0
Mg (1N NH_4OAc)	•	0.1	10	1.0
K (1N NH_4OAc)	•	0.1	10	1.0
Na (1N NH_4OAc)	•	0.1	10	1.0
Ca (0.002M $CaCl_2$)	meq/100g	0.2	5	4.0
Mg (0.002M $CaCl_2$)	•	0.05	10	0.5
K (0.002M $CaCl_2$)	•	0.025	10	0.25
Na (0.002M $CaCl_2$)	•	0.025	10	0.25
Fe (0.002M $CaCl_2$)	•	0.05	15	0.50
Al (0.002M $CaCl_2$)	•	0.2	15	1.3
CEC (1N NH_4OAc)	•	0.25	10	2.5
CEC (0.01M $CaCl_2$)	•	0.25	10	2.5
Acidity ($BaCl_2$-TEA)	•	1.0	15	6.7
Fe (0.1M pyrophosphate)	wt. %	0.03	10	0.3
Al (0.1M pyrophosphate)	•	0.03	10	0.3
Extractable in ammonium oxalate-oxalic acid				
Fe	wt%	0.03	10	0.3
Al	•	0.03	10	0.3
Si	•	0.03	10	0.3
Extractable in citrate dithionite				
Fe	wt%	0.03	10	0.3
Al	•	0.03	10	0.3
SO_4 parameters are not determined for organic samples				
Total S	wt%	0.002	10	0.02
Total N	•	0.015	10	0.15
Total C	•	0.05	10	0.5

(* lower limit MQOs apply below these values of the parameters.)
MQOs for preparation duplicates are 1.5 times and field duplicates are 3 times the values in this table.

irregular boundaries. It is anticipated that clods will be obtained from at least 50 percent of the horizons sampled.

8 SAMPLING PROCEDURES

Sampling procedures are discussed in detail in Section 7 of the Soil Sampling Manual for the DDRP Mid-Appalachian watershed survey (Appendix A).

9 SAMPLE CUSTODY

Samples will be held in the custody of the field crews until the time of shipment. It is expected that crews will normally hold samples for up to 1 week, but may hold samples up to 2 weeks. Crews will be encouraged to send very wet samples to the prep lab as soon as possible. The samples will be placed in coolers that are sealed in cardboard boxes. The boxes are given directly to a courier of a shipping or freight company that guarantees overnight delivery or second day delivery to the prep lab in Las Vegas.

The samples are processed by the prep lab and then sent directly to analytical laboratories. A set of archive samples is kept in a commercial cold storage facility at 4°C in Las Vegas under the supervision of the EMSL DDRP QA staff.

10 CALIBRATION PROCEDURES AND FREQUENCY

There are no instrument calibration procedures involved with these sampling activities. Calibration of pH kits is assured by using fresh indicator solutions.

Crews calibrate the distance of their pacing by measuring their pace length with a tape measure. Calibration of describers' estimates of textural classes, percent clay and rock fragment content is done by experience and by comparison with other crew members' estimates.

11 ANALYTICAL PROCEDURES

The only analytical procedure conducted in the sampling activities is the colorimetric determination of pH. Crews are supplied with pH kits containing chlorophenol red and bromocresol green indicators and color charts. There are no calibration procedures. Quality data are assured by using kits with fresh indicator solutions.

12 DATA REDUCTION, VALIDATION AND REPORTING

The data reduction, validation and reporting associated with the sampling activities are tasks of the prep lab which are described in detail in the prep lab standard operating procedures (Papp and Van Remortel, in press). Site and soil descriptions (232-Forms) are double entered into a computer by personnel at EMSL-LV. A computer program is run by the database manager to check for missing or invalid codes; then entry errors will be corrected. The QA manager at EMSL-LV will summarize discrepancies and will contact the field crew leaders directly for help in rectifying apparent errors. Crew leaders will be asked to approve all corrections or clarifications. The SCS State Soils Staffs will review the descriptions, at the completion of sampling, and suggest modifications in the descriptions or classifications.

The crew logbooks will be reviewed at ERL-C by the QA Coordinator in cooperation with the Sampling Task Leader. The contents of the logbooks will be summarized and validated with the crews at an exit meeting. The summary will be included in a Field Operation and QA Report.

13 INTERNAL QUALITY CONTROL CHECKS AND FREQUENCY

Internal quality control checks are the audits described in Section 11 and independent profile descriptions prepared by the SCS State Soils Staffs and the RCC, which are described more fully in Section 11. The State Soils Staffs will audit each crew in their state at least once. The RCC will audit every crew in the survey at least once. The QA auditors will visit each crew at least once and twice if possible.

Soil profile descriptions will be discussed between crew members as an internal quality control check. Descriptions and labels will be proofread by crew members who did not write them as an additional quality control check.

An internal quality control check on sample labeling will be made when the samples are logged in at the prep lab. A visual check will be made of the label for invalid codes and agreement with the 232-Form. The sample codes will be checked by a computer program for invalid codes and correct preassigned watershed and pedon numbers. Duplicate or invalid codes will be flagged and the field crew will be contacted for clarification.

14 PERFORMANCE AND SYSTEM AUDITS

PERFORMANCE AUDITS

Performance audits are quantitative appraisals of data quality. The performance evaluation samples that are termed low level field audit samples, field audit pairs and field duplicate samples are analyzed to assess data quality.

The analyses of these performance evaluation samples by the prep lab during the time of sampling will provide information that could indicate if there are sources of error being introduced in the field. The data for these performance evaluation samples will be evaluated using the quality levels of the DQOs. The personnel at EMSL-LV, who will analyze the data, will contact the Sampling Task Leader whenever DQOs are not met and he will decide what corrective actions must be taken.

SYSTEMS AUDITS

The following personnel have responsibilities for auditing field crews to verify that all field activities are conducted using the protocols.

Evaluations will be discussed with field crews at the conclusion of the audits so that crews are aware of any potential problems. The QA/QC support personnel have the authority to resolve problems that may affect sample quality during audits. Written reports of the reviews will be documented and submitted by the auditors to the Sampling Task Leader at ERL-C within two weeks. Major problems will be reported orally within two days to the Sampling Task Leader. The form reproduced in the Appendix of the QA Plan, will be used by QA personnel to help document audits.

SCS State Soils Staffs Audits

A representative of each of the SCS State Soils Staff will conduct a field methods evaluation for a minimum of one sampling site per field crew.

Independent pedon descriptions will be prepared by the State Soils Staff to assess soil variability at each site, to evaluate the differences in site descriptions among soil scientists, and to promote consistent application of soil concepts for describing pedons. The State Soils Staff will evaluate any differences between the crew's description and the independent description. If there are any discrepancies that might affect sample quality (most importantly, horizon depths and designations), then the profile descriptions will be discussed with the crew before sampling begins. This will ensure that samples are obtained from the appropriate horizons and labeled with the correct horizon designations. Any changes made to the field crew's profile description will be documented on the 232-Form and in the field crew logbook. The State Soils Staff representative will also monitor adherence to protocols for site selection, labeling, and sampling. The representative will make this assessment while the crew is describing and sampling the pedons. At the end of the audit, all field operations including site location, profile description, and sampling will be discussed with the crew.

Written reports of the field reviews will be documented and submitted by the State Soils Staffs to the Sampling Task Leader at ERL-C within two weeks. Major problems will be reported orally within two days to the Sampling Task Leader.

RCC Audits

The RCC will monitor at least one site per field crew for adherence to NCSS standards and procedures, and for modifications to the sampling protocols presented in this document. The RCC will prepare independent soil descriptions using the same guidelines discussed above for the State Soils Staffs. The RCC will follow the same guidelines for audits as the SCS State Soils Staffs.

The RCC will monitor at least one site in each state in conjunction with the State Soil Staff representative; the remaining sites may be monitored independently. The RCC will ensure that State Soils Staffs perform independent profile descriptions. During this process, the RCC will identify, discuss, and resolve any significant problems.

Written reports of the reviews will be documented and submitted by the RCC to the Sampling Task Leader at ERL-C within two weeks. Major problems will be reported orally within two days to the Sampling Task Leader.

QA Audits

The DDRP QA Coordinator from ERL-C will lead QA audits of field crews and a representative from EMSL-LV may participate in these audits. QA audits will be conducted for each sampling crew at least once near the beginning of sampling and again near the completion, if time permits. The purpose of the audits is to evaluate the adherence to the sampling protocols and to identify and resolve any problems. Independent profile descriptions will not be prepared during QA audits.

Written reports of the reviews will be documented and submitted by the ERL-C DDRP QA Coordinator to the Sampling Task Leader at ERL-C within two weeks and major problems will be reported orally within two days.

15 PREVENTATIVE MAINTENANCE

Sampling crews will clean all tools and sieves after use to prevent rust and sample cross-contamination. Compasses and clinometers must be visually checked for damage periodically. Camera lenses must be kept clean and the camera batteries must be checked periodically. The pumps will be cleaned after use to avoid a dirt accumulation that might damage the diaphragm. pH plates will be cleaned between uses to prevent sample contamination.

16 SPECIFIC ROUTINE PROCEDURES TO ASSESS DATA QUALITY

EVALUATION OF DESCRIPTION DATA

Site and soil descriptions (232-Forms) will be entered into a computer data base at the prep lab and a computer verification program will be run, as discussed in Section 9. The verification program will search for missing values, improper pedon and watershed ID numbers, and invalid codes (Papp and Van Remortel, in press). The descriptions will be entered separately by two different people and the results compared to prevent data entry errors. Data entry errors will then be corrected by the data base manager. The QA manager will summarize any discrepancies and contact the field crew leaders directly for help in rectifying apparent errors.

EVALUATION OF PERFORMANCE EVALUATION SAMPLE DATA

Analysis of the performance evaluation samples will provide some indication whether sample contamination or alteration may have occurred; however it does not, in itself, conclusively indicate why the problem is occurring. Examination of the data generated from the sample obtained immediately prior to handling the performance evaluation sample may provide some indication if there is cross contamination from sampling, sieving and bagging. Examination of the crew logbook Soil Sampling Notes II section will provide information to evaluate sample transport and storage in conjunction with the performance evaluation sample data.

Field duplicate sample data will be compared to routine sample data from the same horizon to evaluate if the variability is within the limits of the MQOs.

QA staff at EMSL-LV will evaluate the pH and LOI values for the performance evaluation samples using the MQOs. Any apparent problems will then be discussed with the Sampling Task Leader at Corvallis, who has the responsibility to initiate corrective actions.

17 CORRECTIVE ACTIONS

All of the auditors of field crews have the authority to correct any practice observed to be performed by field crews that may affect sample quality. The Sampling Task Leader may initiate corrective actions based on the analysis of performance evaluation samples.

Corrections to field data forms (232-Forms) are first submitted to the crew leaders for comment and approval. Corrections to sample labeling may be made by QA staff at the prep lab in Las Vegas. The Sampling Task Leader must be informed of needed corrections.

18 QUALITY ASSURANCE REPORTS TO MANAGEMENT

A written report must be submitted to the Sampling Task Leader for every audit conducted. These reports must be submitted within two weeks of the audit and major concerns from the audits must be verbally reported to the Sampling Task Leader as soon as possible.

A field operations report will be written by DDRP staff at ERL-C.

19 REFERENCES

Bartz, J.K., S.K. Drouse, K.A. Cappo, M.L. Papp, G.A. Raab, L.J. Blume, M.A. Stapanian, F.C. Garner, and D.S. Coffey. 1987. Direct/Delayed Response Project: Quality Assurance Plan for Soil Sampling, Preparation, and Analysis. USEPA/600/8-87/021. U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Las Vegas, NV.

Coffey, D.S., M.L. Papp, J.K. Bartz, R.D. Van Remortel, J.J. Lee, D.A. Lammers, and G.R. Holdren. 1987a. Direct/Delayed Response Project: Field Operations and Quality Assurance Report for Soil Sampling and Preparation in the Northeastern United States, Volume I Sampling. EPA/600/4-87/030. US Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Las Vegas, NV.

Coffey, D.S., J.J. Lee, J.K. Bartz, R.D. Van Remortel, M.L. Papp, and G.R. Holdren. 1987b. Direct/Delayed Response Project: Field Operations and Quality Assurance Report for Soil Sampling and Preparation in the Southern Blue Ridge Province of the United States, Volume I Sampling. EPA/600/4-87/041 US Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Las Vegas, NV.

Kern, J.S. D.A. Lammers, D.L. Cassell, and W.G. Campbell. 1990. Direct/Delayed Response Project: Field Operations and Quality Assurance Report for Mapping in the Mid-Appalachian Region of the United States. EPA/600/3-90/035. US Environmental Protection Agency, Environmental Research Laboratory, Corvallis, Oregon.

Papp, M.L., R.D. Van Remortel, C.J. Palmer, G.E. Byers, B.A. Schumacher, R.L. Slagle, J.E. Teberg and M.J. Miah. 1989. Direct/Delayed Response Project: Quality Assurance Plan for Preparation and Analysis of Soils from the Mid-Appalachian Region of the United States. EPA/600/4-89/031. US Environmental Protection Agency, Las Vegas, Nevada

Quality Assurance Management Staff. 1980. Interim guidelines and specifications for preparing quality assurance project plans, QAMS- 005/80. U.S. Environmental Protection Agency, Washington, DC., 37 pp.

Soil Survey Staff. 1984. Soil Survey Laboratory Methods and Procedures for Collecting Soil Samples. U.S. Department of Agriculture, Soil Survey Investigations Report No. 1. US Government Printing Office, Washington, DC.

Soil Survey Staff. 1983. National Soils Handbook. US Government Printing Office, Washington, DC.

Taylor, J.K. 1987. Quality Assurance of Chemical Measurements. Lewis Publishers Inc., Chelsea, Michigan.

20 AUDIT FORM FOR QA PERSONNEL

This form is for use by the SCS State Soils Staffs, the RCC and the QA Auditors. It is based on the form developed by D.S. Coffey, of the ERL-C QA Staff, for the DDRP SBRP Soil Survey which is reproduced in Appendix D of the DDRP QA Plan for the Soil Sampling, Preparation and Analysis (Bartz et al., 1987). The form was slightly revised by J.S. Kern to reflect changes in protocols made since the SBRP survey.

Soil Sampling Audit Evaluation Form
For the DDRP Mid-Appalachian Soil Survey

General Information (Page 1 of 1)

Date:______________________ State:______________________

Crew ID:______________________ Watershed ID:______________________

Time of arrival at site:__________ Time of departure:____________

Field Crew:
Names

____

____

____

____

____

Audit Team:

Name(s)	Crew
Leader:______________________	
______________________	______________________
______________________	______________________
______________________	______________________

Notes or Comments:

____

____

____

____

____

____

____

Site Selection

Equipment

Item	Used in Field?		Comments
	Yes	No	
Screw auger			
Bucket auger			
Punch probe			
Aerial photographs*			
Stereoscope			
Compass			Adjustable for declination?
Topographic map			
Map of sampling sites*			
Random number table*			
Letter to landowners*			

Other site selection equipment used:

* Supplied by EPA

Site Selection

Procedure (Page 1 of 1)

Item	Yes	No	Comments
Does the crew have a map from EPA of starting points?			
Was the landowner contacted?			
How does the crew locate sampling points?	NA	NA	
Does the crew attempt to locate starting points in order?			
Are the numbers of the points and directions taken documented?			In logbook? Final point on bottom of pg 1 of 232?
Is the vegetation cover evaluated correctly?			
If used, how were random points chosen?	NA	NA	
If used, how were 10 m intervals determined for transects?	NA	NA	
Were the crew members familiar with and did they understand the procedures?			
How many compass points were used for each starting point?			

Comments:

Pedon Excavation

Equipment (Page 1 of 1)

Item	Used in Field?		Comments
	Yes	No	
Shovels			
Sharpshooters			
Picks			
Digging Bars			
Hand pump (Beckson Gusher*)			
Post hole digger			
Backhoe			

Other pedon excavation equipment used:

* Supplied by EPA

Pedon Excavation

Procedure (Page 1 of 1)

Item	Yes	No	Comments
Did the crew minimize disturbance to the side of the pit face to be sampled?			
Is the excavated pit of suitable size? (1m x 2m or to bedrock)			
Does this pit have a high watertable problem? If yes, what was done to control sample contamination?			
Is this a histosol? If yes, how was it excavated?			

Comments:

Soil Profile Description

Equipment (Page 1 of 1)

Item	Used in Field? Yes	 No	Comments
SCS 232-form			
Clipboard			
Munsell color chart			Condition?
Compass			set for declination? what is it?
Clinometer			
Hand lens			
Knife, ice pick, etc.			
pH kit*			kind? indicators? (how old?)
Peat sampler			
Orange flagging*			
Stake wire flags*			
Golf tees*			
Indelible ink markers*			

Other soil description equipment used?

* Supplied by EPA

Soil Description

Procedure (Page 1 of 2)

Item	Yes	No	Comments
Is the pit face cleaned before description?			
Does the crew examine only the pit face?			
Is the horizon depth measured from an accurate zero-point at the top of the profile?			Specifically where?
Over what range is the horizon thickness determined?			
How is color determined?			
Is the 232-form filled in completely? legibly?			
Who recorded the 232-form data?			

Comments:

Soil Description

Procedure (Page 2 of 2)

Item	Used in Field?		Comments
	Yes	No	
Is the compass used for azimuth determination?			
How was the declination value determined?			
Are the 232 codes adequate for all situations encountered?			
Was any of the 232 filled out before arrival in field?			

Comments:

Independent Descriptions

Discuss any differences observed between the routine description and the independent description:

Are any of the observed differences significant to affect sample quality? These must be discussed with crew before sampling begins.

Photographic Documentation

Equipment (Page 1 of 1)

Item	Used in Field?		Comments
	Yes	No	
35 mm camera, automated with flash* If different camera used - what type?			
Slide film ASA __________			
Photogray card*			
Khaki measuring tape*			
White golf tees			

Other photographic equipment:

* Supplied by EPA

Photographic Documentation

Procedure (Page 1 of 1)

Item	Yes	No	Comments
Are photos taken before profile is disturbed for sampling?			
Are horizon boundaries marked by white golf tees?			
Is the khaki measuring tape properly aligned for the photographs?			
Is the photogray card properly filled out?			
Is the photogray card placed at top of profile for photographing?			
Are slides documented in the crew logbook?			
Are the slide numbers documented on p. 4 of the 232-form?			
Are the 4 required (minimum) photos taken:			
pedon face?			
tree canopy?			
understory veg?			
landscape/landform?			
Was a flash necessary?			

Comments:

Soil Sampling

Equipment (Page 1 of 1)

Item	Used in Field?		Comments
	Yes	No	
Post hole digger (for histosols)			
1 brass sieve (20-mm)*			
2 - 1 gallon buckets*			
Spatula or knife			
Wire brush and paper towels			
Plastic inner bags*			
Cloth exterior bags*			
DDRP Label A's*			
Staplers*			
Dust pan or dish			
Hand trowel*			
Garden trowel			
Hole punch*			
Bucket auger			

Other equipment used:

Soil Sampling

Procedure (Page 1 of 3)

Item	Yes	No	Comments
Are all important horizons sampled?			
Were adequate organic samples obtained?			
Were adequate mineral samples obtained?			
What horizons were sampled (in order taken) __________ __________ __________ __________ __________ __________	NA	NA	

Comments:

Procedure (Page 2 of 3)

Item	Yes	No	Comments
Was the pedon sampled in such a way to avoid sample contamination?			If no, give detailed explanation
Was the soil sampled into a pan, then examined before sieving?			
Were the pan and sieve cleaned after each sample?			
Were any bags split for sampling? If yes, why? >30 cm thick? (above 1m) >60 cm thick? (below 1m)			
Are sample bags correctly closed?			
Are samples correctly labeled?			

Comments:

Procedure (Page 3 of 3)

Item	Yes	No	Comments
Was a field duplicate taken?			If yes, how was it handled?
Were field audit samples handled?			If yes, how were they handled?
Were rock fragment classes and volumes determined correctly?			
Were there any problems or concerns with the sampling protocols identified?			

Comments:

Bulk Density Sampling Was this method used? ____ Yes ___ No

Clod Method - Equipment Page 1 of 1)

	Used in Field?		Comments
	Yes	No	
Saran* Mixture ratio? What stored in?			
Hairnets?*			
Plastic bags*			
Clod box*			
Rope			
Labels* on clods on clod box			
Scissors or pruners			

Comments:

* Supplied by EPA

Bulk Density Sampling

Clod Method - Procedure (Page 1 of 1)

Item	Yes	No	Comments
Were 3 clods obtained for each horizon?			If no, why?
Were clods of sufficient size?			
Were clods handled correctly?			
Were clods dipped in saran for 2 seconds?			
Were the number of dips recorded on the tags?			
Were clods labeled correctly?			
Were clods dry when packaged?			
Was the clod box labeled correctly?			
Were clods padded sufficiently?			

Comments:

Bulk Density Sampling Was this method used? ____ Yes ___ No

Volume-Replacement Method - Equipment (Page 1 of 1)

Item	Used in Field?		Comments
	Yes	No	
Plastic graduated cylinder, 2 liter*			
Plug for cylinder*			
Metal frame*			
Straight-edge			
Garden trowel			
Cheesecloth			
Beads*			
Plastic inner bags*			
Cloth exterior bags*			
DDRP Label A*			
Field Data Sheet* (for when using frame)			

Comments:

* Supplied by EPA

Bulk Density Sampling

Volume-Replacement Method - Procedure (Page 1 of 1)

Item	Yes	No	Comments
Can a level step be prepared or is the frame necessary?			
If used, was the frame anchored correctly?			
If used, was the frame calibrated correctly?			
Was all the excavated soil carefully bagged?			
Are all samples labeled correctly?			
Did the crew carefully tamp the beads in the cylinder?			
Did the crew carefully read cylinder volumes?			
Did the crew record the cylinder volumes?			On the 232? On the Date Sheet (if using frame)?
Did the crew carefully line the holes with cheesecloth and gently tamp beads while filling?			
Did the crew level off the tops of holes and the frame when filled with beads with a straight-edge?			

Comments:

Why was the crew unable to obtain clods?

Bulk Density Sampling

Was this method used? ____ Yes ___ No

Volume-Filling Method - Equipment (Page 1 of 1)

Item	Used in Field? Yes	 No	Comments
Containers of known volume*			What size?
Straight-edge			What was used?
Plastic inner bags*			
Cloth exterior bags*			
Garden trowel			
DDRP Label A*			

Comments:

* Supplied by EPA

Bulk Density Sampling

Volume-Filling Method - Procedure (Page 1 of 1)

Item	Yes	No	Comments
How did the crew fill the container?	NA	NA	
Did they fill it to the rim?			
Did they strike off the top with a straight-edge?			
Did they transfer all the material to a bag?			
Did the crew correctly label the samples?			
Did they place all the replicates for a horizon in the same cloth bag?			

Comments:

Why was the crew unable to obtain clods or volume-replacement samples?

Sample Transport, Storage and Shipment

Equipment (Page 1 of 1)

Item	Used in Field?		Comments
	Yes	No	
Backpacks or daypacks			
Styrofoam coolers*			
Gelpacks*			
Truck or car			
Sample shipping form* (photocopy crew logbook)			
Address labels to ERL-C*			
Courier forms			
Envelopes, 8.5 x 11 inch			

Other equipment used:

* Supplied by EPA

Sample Transport, Storage and Shipment

Procedure (Page 1 of 1)

Item	Yes	No	Comments
How were samples carried from the site to the vehicle?	NA	NA	
How are clods transported?	NA	NA	
Were any sample bags damaged in handling?			
Were samples stored or shipped to prep lab?			If stored, describe facility.
If shipped, was the shipping form correctly filled out? If not shipped, examine logbook.	NA	NA	
Does the crew understand that the original 232 goes to Las Vegas and a copy to Corvallis?			
When shipped are the 232 and shipment form taped to outside of styrofoam cooler in bag?			
Has the crew been sending the watershed map with final sampling location marked to Corvallis?			
Were there any problems the past with: Sample bag breakage? Gel-pac leakage? Cross-sample contamination?			

Comments:

Summary (Page 1 of 1)

Summary Comments:

Areas of Concern:

Concerns that should be reported to the Sampling Task Leader (with suggested resolution if appropriate):

APPENDIX C:

DIRECT/DELAYED RESPONSE PROJECT: REGIONAL COORDINATOR/CORRELATOR QUALITY ASSURANCE REPORT FOR SOIL SAMPLING IN THE MID-APPALACHIAN REGION

by

John W. Warner, Jr

Soil Scientist, Consultant

Marco, Florida

TABLE OF CONTENTS

1 COORDINATION OF SAMPLING ACTIVITIES 1

Sampling Crew Training 1

2 SAMPLING ACTIVITIES 3

Site Restrictions 3

Sampling Restrictions Related To Soil Characteristics 3

Equipment 3

Site and Soil Profile Description Forms 3

Crew Logbooks 4

Sample Storage and Shipment 4

3 RCC SAMPLING AUDITS 5

Audit of PA01 5

Audit of PA02 6

Audit of WV01 8

Audit of WV02 9

4 OVERALL SUMMARY AND RECOMMENDATIONS 11

1 COORDINATION OF SAMPLING ACTIVITIES

The Regional Coordinator/Correlator (RCC) participated in the final correlation workshop for the mapping in the Mid-Appalachian Region of the Direct/Delayed Response Project (DDRP) on August 22 and 23, 1988, at the US Environmental Protection Agency (USEPA) Environmental Research Laboratory, Corvallis, OR (ERL-C). Upon completion of the correlation, the RCC assisted with the development of sampling classes for the Mid-Appalachian Region. After developing the various sampling classes, the RCC assisted with assigning sampling classes to the map unit components used in this survey. The RCC participated in the revision of sampling class definitions to prepare the final sampling class flowchart.

The RCC participated in, and assisted with, the sampling training workshop that was held at State College, PA, on September 6 to 8, 1988. All key personnel involved in sampling in PA, WV, and VA attended the workshop.

The RCC was not called upon to coordinate sampling activities within or between states or with USEPA personnel in Corvallis. The RCC did not participate in any conference calls relating to the coordination of the sampling activities. The RCC was involved full-time in mapping evaluation and audits of the US Department of Agriculture - Soil Conservation Service (SCS) sampling crews and thus was not available to participate in conference calls.

Sampling Crew Training

The RCC participated in, and assisted with, the sampling training workshop held at State College, PA. Some training was provided during audits; however, this training was minimal in nature because the sampling crews had already completed sampling several pedons prior to the audits and were well aware of the protocols.

It is suggested that each state devote at least one day to sampling training with all sampling crews brought together at a sampling site to complete sampling a pedon, including site selection. This would give the crews an opportunity to receive hands-on training prior to the initiation of sampling. The RCC and/or USEPA personnel could participate in these sessions and it would be effective in providing training. The sampling audits were designed to check the crews sampling procedures and, as such, were not designed to provide training. The audits should be performed after a crew has become proficient in sampling, rather than early in the sampling when they were developing their sampling techniques.

2 SAMPLING ACTIVITIES

Site Restrictions

There were no cases where sites were found to be inaccessible during the RCC audits. No pedons were sampled that did not match the preselected sampling class, vegetative cover, or other considerations such as correct sampling site. The sites were made more difficult to select on Upper Dry Hollow Watershed, PA, due to the receipt of the wrong map. The correct site locations were relayed to the sampling crew during a phone conversation with USEPA and did not delay sampling.

Sampling Restrictions Related To Soil Characteristics

The sampling audit with crew PA02 was initially scheduled to be on sampling class TWD (mapped as Bedington series); however, after attempting to dig at 2 pit sites, the site was abandoned due to large boulders at a depth of about 1 m in the profile. In order to complete the sampling audit, the crew moved to a previously selected site mapped as Berks series (sampling class BMK). There were no other cases during the RCC audits where soil characteristics forced the crews to abandon the preselected sampling site.

Equipment

All the crews were well equipped to perform all sampling operations. A backhoe was used for some of the sampling sites in PA. This eased and sped up excavation of sampling sites.

Site and Soil Profile Description Forms

All pedon descriptions were prepared on the USEPA modified version of the SCS 232-forms. Newness of the forms and the participants lack of familiarity with the form resulted in some erroneous entries. These erroneous entries were corrected at the exit meeting.

Crew Logbooks

Only essential pages of the logbooks were taken out in the field during sampling operations with the remainder completed later at the office. Therefore, there was not the opportunity for the RCC to check a fully completed notebook during audits.

Sample Storage and Shipment

Crew PA01 stored the samples in styrofoam coolers with frozen gel-packs with plans to ship the samples at the end of the week. Crew PA02 stored samples in coolers with frozen gel-packs and then shipped them the next day. Both WV crews obtained refrigerated storage and shipped samples the first day of the following week.

3 RCC SAMPLING AUDITS

Audit of PA01

The sampling audit of crew PA01 was made on September 21, 1988, on Upper Dry Hollow Watershed, PA (2C029002). The sampling class was TWD and the soil series samples was Lech Kill. The SCS State Soils Staff participated in the review and also completed a Soil Sampling Audit Evaluation Form (Appendix B) and an independent soil profile description on a 232-Form.

The procedures for the site selection were correctly performed using aerial photographs and topographic maps, with a compass and pacing to locate the primary point. The crew had been provided with the wrong location map, and it was necessary to plot the sampling points though a telephone conversation with USEPA, but this did not delay the sampling. Point One was established as the sampling site; therefore, it was not necessary to make random transects from the starting point to find the assigned sampling class.

The sample pit was excavated with hand tools to bedrock at 122 cm. The pit was excavated in accordance with protocols and care was taken to insure minimum disturbance to the sampled face. The pedon was described by the crew leader, with independant pedon descriptions prepared by the RCC and SCS State Office Representative. The only differences of any note between the crew leaders description and the RCC independent description was the inclusion of a BC horizon in the RCC's description. The same zone was described as part of the Bt horizon in the routine description. This difference resulted in a loamy-skeletal textural family in the routine description and a fine-loamy textural family in the RCC description. This difference was not considered to be significant to affect sample quality. In sample class TWD, skeletal and non-skeletal soils are not distinguished separately. Complete and specified photographic documentation was accomplished in accordance with protocols.

Sampling was accomplished in accordance with protocols. Care was taken to avoid sample contamination among horizons in the profile. Two bags of soil were sampled from horizons with excessive rock fragments to insure adequate sample size. Field duplicate samples were not taken or audit samples handled at the site. Clods were obtained from each horizon for bulk density determinations. The soils were very friable or friable and large clods were difficult to obtain. The ability to get useful clods was questionable due to very high rock fragment content in the lower horizons (BC and C). Volume-fill and volume-replacement bulk-density procedures were not used at this site. The clod samples were placed in compartmented clod sample boxes at the pit site.

The samples were hand carried from the sample site to the vehicles and transported back to the crew's motel. Upon returning to the motel the crew packed the samples in styrofoam coolers with frozen gel-packs. Their plans were to take the samples back to their headquarters for shipment to the preparation laboratory. I suggested that samples be shipped more frequently and, if possible, on the next day after sampling to avoid the necessity for maintaining lowered temperatures for extended periods. The sample crew did a thorough and conscientious job of sampling and will, in my opinion, continue to obtain soil samples that will contribute meaningful soil data to the project.

Part of September 22 was spent with the sample crew but not as an audit. The ERL-C QA Coordinator was performing a sampling audit and I discussed my findings of the previous day with him. The soil being sampled was mapped as Basher; however, the sample site was skeletal and better fit the concepts of Craigsville soil. Basher and Craigsville are in the same sample class and the name difference would not affect sampling.

Audit of PA02

A sampling audit was made of crew PA02 on September 28, 1988, on Burns Creek, PA (2B036-026). The sample class was BMK and the soil series sampled was Berks. A PA SCS State Office Representative participated in the review and also completed a Sampling Audit Evaluation Form and an independent soil pedon description on 232-form.

The procedure for site selection was correctly performed. The primary point had been established prior to the audit; however, inspection of the location map and aerial photos indicated the initial point to be correctly located. The soil at the starting point was too deep; therefore, it became necessary to randomly select a direction and transect to obtain a soil in the correct sample class. The transect was along an east heading from starting point one. The soils were checked at 10 m intervals and the correct sample class was established at the fourth stop along the transect. This was a second sample site in the watershed that was visited for the audit. The crew originally planned to sample class TWD (mapped as Bedington series) during the audit but due to large boulders interfering with digging at the TWD sample site the decision was made to move to the Berks sampling site to save time for the completion of the audit. The Berks was on the same farm as the Bedington and permission had already been obtained to sample. The crew planned to sample TWD at a later date and, if necessary, at one of the other designated sites.

The sample pit was excavated with hand tools to bedrock at 55 cm. The pit was excavated in accordance with protocols and care was taken to insure minimum disturbance to the sampling face. The pedon was described by the crew leader, with independent pedon descriptions by the RCC and SCS State Office Representative. The only difference between the RCC independent description and the routine description was horizon designation below a depth of about 27 cm. The horizons designated Bw2 and BC in the RCC description was combined as a C horizon in the routine description. The difference results in 3 horizons being sampled rather than 4. This difference was not considered to be significant and the sampling was done in accordance with the crew leaders description. It was felt that three samples would adequately characterize the soil. Complete and specified photographic documentation was accomplished in accordance with the protocols.

Sampling was accomplished in accordance with protocols. Care was taken to avoid sample contamination among horizons in the profile. The Bw was split for sampling due to > 45 percent rock fragment content. A field duplicate sample was taken. The total horizon was sampled, mixed and then subdivided into 2 sample bags (which is not exactly according to protocols). Field audit samples were handled after each horizon was sampled. Clods were obtained from each horizon for bulk density determinations. The clods were obtained and processed in accordance with protocols. Volume-fill and volume-replacement procedures were not used at this site. Clods were placed in compartmented clod sample boxes at the pit site.

The samples were transported from the site by vehicle. Upon returning to the crew's office the samples were packed in styrofoam coolers with frozen gel-packs. The samples were to be shipped to the preparation laboratory on the following day, making it unnecessary to obtain refrigerated storage. The sample crew did a thorough and conscientious job of sampling. Nothing was observed in their techniques or procedures that will cause any problems with future sampling.

Audit of WV01

A sample audit was made of crew WV01 on October 5, 1988, on Club House Run, WV (2C047-010). The sample class was FLW and the soil series sampled was Craigsville. The procedure for site selection was correctly performed. The primary point had been established and the pit partially excavated prior to the audit. The location of point one was transferred from the USEPA location map to an aerial photo and the point established by air photo image. The point was checked and found to be accurately located. The designated sampling class was at point one; therefore, it was not necessary to transect to establish the sample point. The specified forest cover was hardwood which was at the sample site but numerous hemlocks were scattered throughout the area.

The sample pit was excavated with hand tools to a depth of 152 cm. The 2C horizon contained many flagstones making excavation to 2 m impractical. Also water seeped into the pit at a depth of about 125 cm requiring continual pumping to keep the water level below a depth of about 1.5 m. Except for depth, the pit was excavated in accordance with protocols and care was taken to insure minimum disturbance to the sampled face.

The pedon was described by the crew leader, with an independent soil pedon description prepared by the RCC. Differences between the routine description and the RCC description was a 2 to 5 cm thick layer of loamy fine sand on the surface. This surface layer was covered in the RCC notes and not described as a separate horizon. The 48 to 91 cm layer in the routine description was described as a 2C1 horizon. The same layer was described as a 2BC in the RCC description. The 2C was described as a single horizon in the RCC description. The lower part was separated into 2C3 and 2C4 in the routine description for sampling. The above differences do not affect sampling or correct classification of the pedon for sampling class. Complete and specified photographic documentation was accomplished in accordance with protocols.

Sampling was accomplished in accordance with protocols. Care was taken to avoid sample contamination among horizons in the profile. The water moving freely through voids in the 2C horizon may have caused some inter-horizon contamination below about 1 to 1.5 m but the crew made every effort to avoid any contamination. Field duplicate samples were not taken from the BA, Bw, and 2C1 horizons. Two volume-replacement samples were taken from the BA horizon to fulfill the requirement for 4 trial clod and volume-replacement samples from the same horizons for comparison of the two methods. Cheesecloth was used to line one hole in volume-replacement.

The cheesecloth was too narrow and the second hole was not lined prior to filling. The volume-filling method was used on the surface layer (C horizon) and the Ab horizon as the horizons were too thin for volume-replacement and too loose for clods. The clods were placed in compartmented clod sample boxes at the pit site.

The samples were transported back to the crews' headquarters and placed in refrigeration to hold until shipped to the preparation laboratory the following Monday.

The sample crew was doing a very satisfactory job. Above average care was taken to insure adequate uncontaminated samples. Work by the crew will result in samples that will prove very useful to the project.

Audit of WV02

The sample audit of crew WV02 was made October 6, 1988, on Right Fork of Clover Run, WV, watershed 2C041045. The sample class was TWM and the soil series sampled was Gilpin. A SCS State Office Representative also participated on the review and completed a Sampling Audit Evaluation Form and an independent soil pedon description on a 232-form.

The procedure for site selection was correctly performed. The primary point had been located by the crew leader and marked with tape. The site was located by comparing recognized landscape features to the topographic map. The site was on a very steep wooded mountain side with no definite landmarks for pacing. The site was checked and found to be accurately located. The designated sampling was at point 1, therefore, it was not necessary to make random transects to locate the assigned sample class. The forest cover type was as specified.

The sample pit was excavated with hand tools to bedrock at a depth of 84 cm. The pit was excavated in accordance with protocols and care was taken to insure minimum disturbance to the sampled face. The pedon was described by the crew leader with independent descriptions by the RCC and SCS state office representative. The only differences between the crew leader's description and the RCC's description was the subdivision of the Bt as a Bt1 and Bt2 in the RCC description. The

Bt was not subdivided in the routine description. Also the total Bt thickness in the RCC description was 37 cm and in the crew leader's it was 29 cm. Using the crew leaders description resulted in one less sample since the Bt was not thick enough to require subdivision. The differences are not significant to sampling class identification or securing an adequate sample for series characterization. The crew leader's description was used as originally written for sampling. Complete and specified photographic documentation was accomplished in accordance with protocols.

Sampling was accomplished in accordance with protocols. Care was taken to avoid sample contamination among horizons in the profile. Field duplicate samples were not taken or audit samples handled at this site. Clod samples were taken from each horizon for bulk density determinations. Clods from the A horizon were quite small (less than specified in protocol). Clods from the BA and Bt horizons were good. Clods from the C horizon are largely rock fragment. Volume-filling and volume-replacement procedures were not used at this site. Clods were placed in compartmented clod sample boxes at the pit site.

The samples were hand-carried back to the vehicles and transported to the crew's motel. The samples were placed in refrigerated storage at a grocery store at Parsons, WV, and held for shipment to the preparation laboratory on the following Monday.

The sample crew was doing a very satisfactory job. Their work resulted in samples that will prove very useful in the project. Upon completion of sampling, the audit team accompanied the sample crew to the next sample site and observed the crew leader's technique for locating the primary sample site. This site was also in a heavily wooded area quite some distance from easily identified land marks. The crew leader primarily used topographic lines on a site map to locate point one. From observations, the sample site was correctly located. The pit was partially excavated preparatory to sampling the following day.

4 OVERALL SUMMARY AND RECOMMENDATIONS

Based on observations made during the four audits, the soil sampling project will prove to be very successful. The sample crews did a very careful job in obtaining the samples and can be expected to continue the same degree of care for the remainder of the sampling effort. The analytical data will prove very useful in the project and this is largely due to careful and conscientious sampling by the sampling crews.

The amount of time devoted to sample audits by the RCC is appropriate with respect to on-site evaluation of sampling. However, I feel that the RCC can contribute more to the sampling program in a training capacity than in an audit capacity. The RCC visits would likely be more useful if made early in each crew's sampling to help develop sampling techniques, interpret protocols, and answer questions. If a sample crew is not inclined to exercise adequate care in sampling, it is unlikely that audits will change their techniques except during the audit.

Basically, I feel that the purpose of the audit is to insure that the sample crew has a complete and thorough understanding of the requirements of the protocols. Therefore, 2 sample audits or training visits to each crew (1 by the RCC and 1 by the QA representative) should be adequate. Additional audits would slow the sampling efforts.

The independent pedon descriptions will serve to provide a comparison between or among the individuals preparing the descriptions. The descriptions cannot and should not be used to indicate that one description is correct and another incorrect. The differing descriptions can be used to determine if the describers agreed on field measured soil properties or characteristics in placing the soil in a specific sampling class. Evaluation of laboratory analytical data may reveal that all describers incorrectly classified the pedon in question, for example, a cambic horizon versus an argillic horizon. Also, to avoid excessive delay in completing sampling, independent descriptions were prepared more hurriedly than the crew leader's description.

From the RCC point of view, the QA activities were sufficient to indicate that each of the four sample crews visited was doing a very conscientious and careful job.